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A Study in Transportation with Reference to the Economical Handling of Ores for the Plant of Greene Consolidated Copper Company

by Victor Roy Walling

1911

Submitted to the School of Chemical Engineering of the University of Kansas in partial fulfillment of the requirements for the Degree of Bachelor of Science

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A STUDY IN TRANSPORTATION

V. R. WALLING
1911

A STUDY IN TRANSPORTATION

with reference to

the Economical Handling of Ores

for

the Plant of

THE GREENE CONSOLIDATED COPPER CO.

at

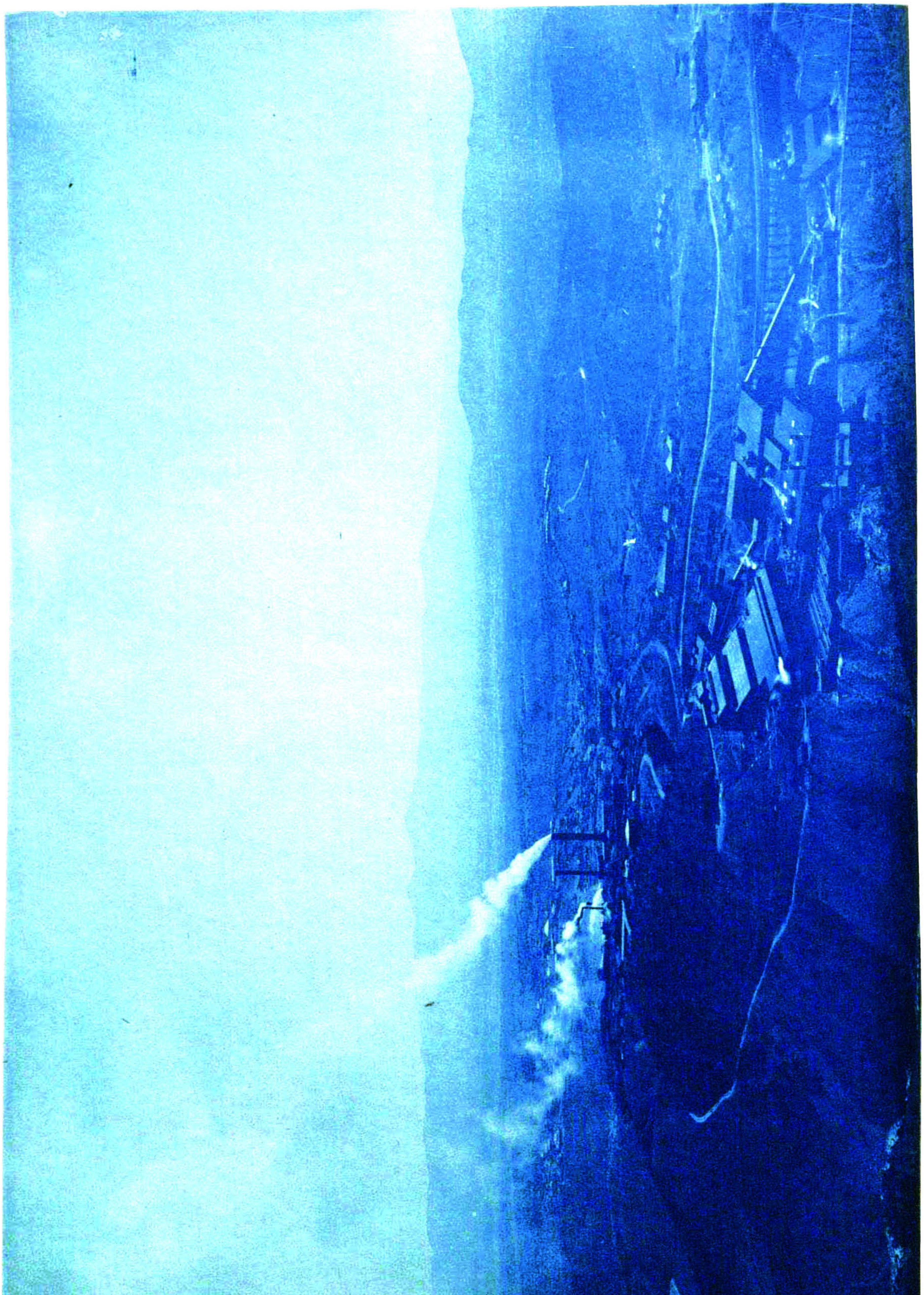
CANANEA, SONORA, MEXICO.

V.R.Walling, '01.

1911.

For C.E. Degree

Engineering Library



A STUDY IN TRANSPORTATION

One of the oldest problems in the world and a problem that daily becomes more important as a factor in the world's progress, is that of transportation. It began with the formation of the earth, and the gently sloping mountain sides and the productive lowlands of the present day give testimony of this ever present force of nature, through erosion and the transportation of the soil. In biblical times we are reminded of it by the eviction of Adam and Eve from the Garden of Eden, for doubtless the transportation facilities of that day worried Adam not a little. Little Moses calmly floating down the River Nile in his basket of rushes reminds us of the early application of the water route as a means of transportation.

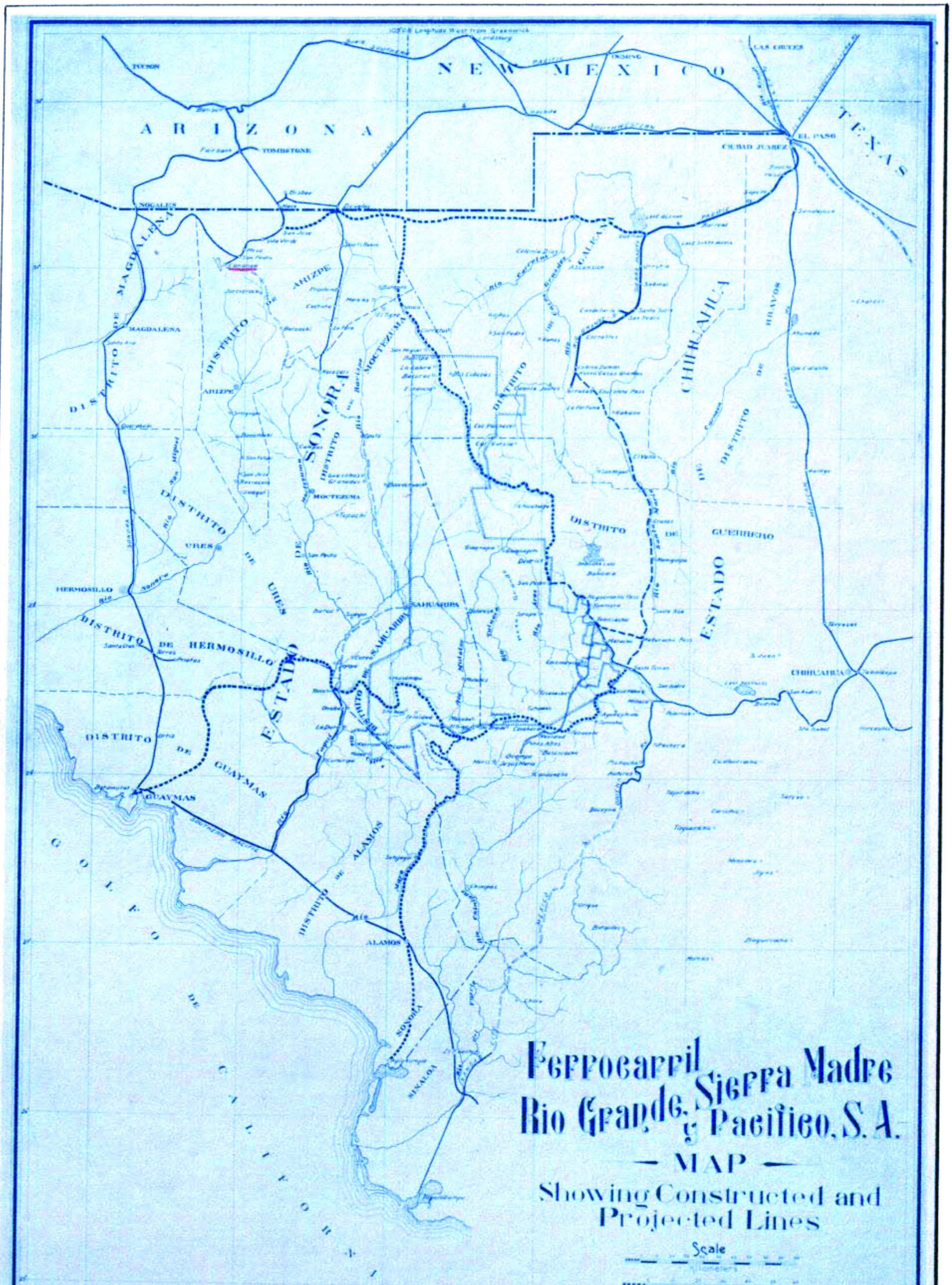
The remains of stone roads in England indicate that Caesar himself was a student of this problem, although from their construction it would appear that the question of economy was not a vital one. The products of the wonderful Far East were brought to Europe by laborious caravan and caravel, and the discovery of America by Columbus was largely due to an attempt to discover a north west passage to India whereby these products might be more easily and cheaply transported, which indicates economy in transportation began to have its influence.

Throught successive steps the inventive mind produced improvements in sailing vessels, and brought forth the steamship, the railroad, the automobile and now the conquering of the air; but the incentive for it all is that man and his freight might be transported more easily, quickly and cheaply. The science of Engineering owes its present high standing among the sciences to the impetus given it by the intricacies of this question and with some, at least, of the fundamental problems solved, has come the effort to reach the highest attainment in their development. The increasing population of the world and the demands made by it for not only quick transportation for themselves, but for their products and supplies as well, has produced competitors of transportation. The law of the survival of the fittest has practically reduced the problem to quickness and cost of delivery, and to this end millions of dollars are being spent annually.

As examples of the work being done on this problem, whose sole object is rapid and economical transportation, we have but to refer to the many changes of main line being undertaken by all important bidders for traffic, whereby grades and curvature may be reduced. The Lucin cutoff on the Union Pacific Railroad offers a striking illustration. By spending $10,000,000.00 to make a roadbed across the Great Salt Lake, a transcontinental line has been shortened forty four miles, and fifteen hundred feet of heavy grade and three thousand nine hundred and nineteen degrees of curve have been eliminated. The expenditure effects an annual saving of nearly one million dollars in the operating economy of the road.

Another phase of the problem may be seen in the tremendous expenditures made by the Pennsylvania Railroad in driving tubes under the Hudson River and establishing a railway station in the heart of New York City, that congestion of traffic might be reduced.

The transportation dream of a century has been the piercing of the Isthmus of Panama, and today the United States Government is spending millions of dollars annually that this dream may be realized. Already the effect the successful completion of this problem will have upon the competitors in the transportation world may be seen in the recent announcement that the Union Pacific Railroad will spend $75,000,000.00 in the next five years in double tracking their system from the Missouri River to the Pacific Coast. Thus in order that the Union Pacific may compete with steamship transportation

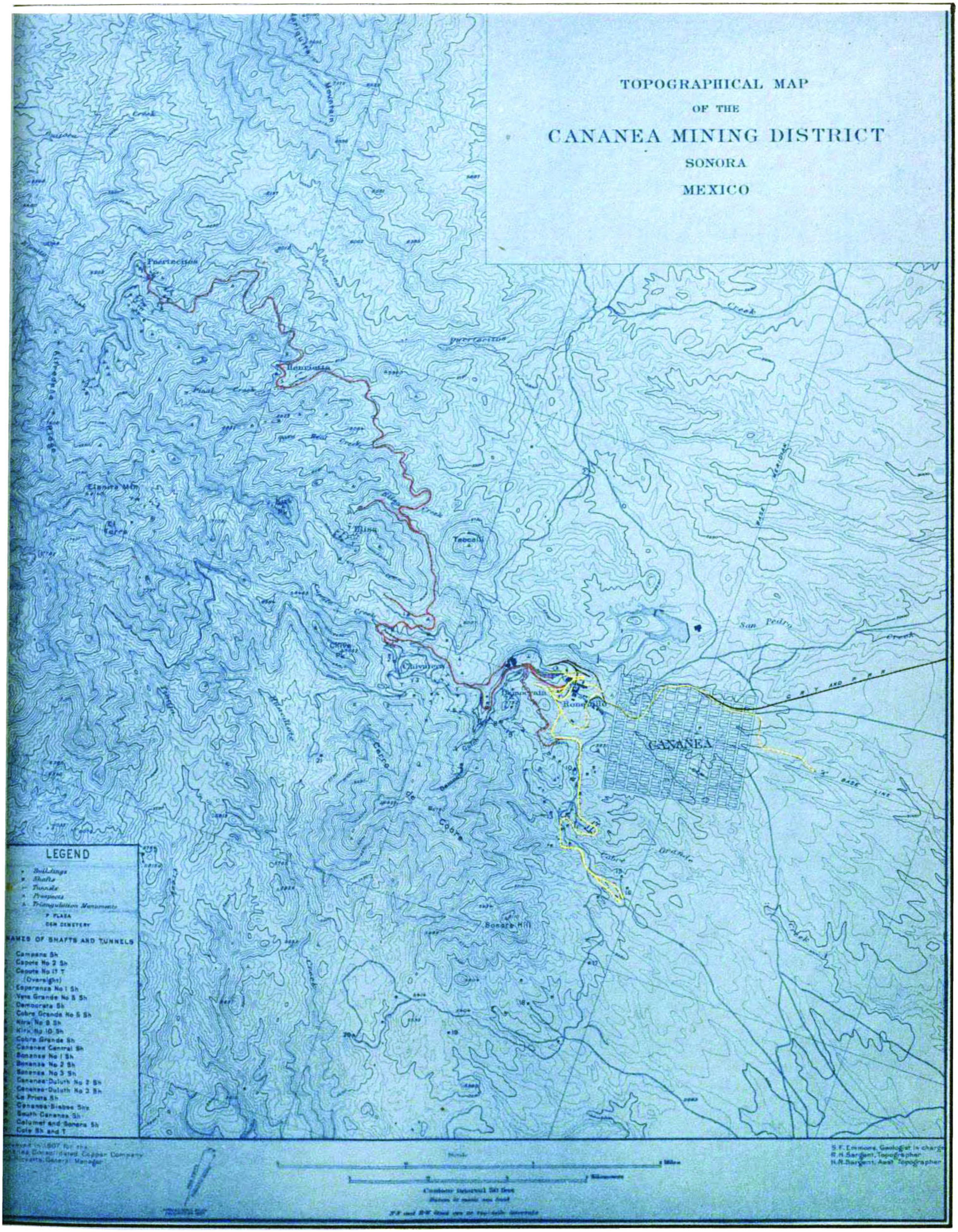


"ON THE BORDER", STATES OF SONORA & CHIHUAHUA, MEXICO.

via Panama, their line will be double tracked; this will force other trans-continental single track lines to double track their systems, that they in turn may compete with the Union Pacific. These are some of the answers to the many sided problem of rapid and economical transportation.

In this paper will be discussed the economical handling of the ores for the plant of the Greene Consolidated Copper Company at Cananea, Sonora, Mexico, with reference to the reduction in cost per ton and the reforms that have brought about the cheaper transportation of the ore. It is a long jump from the problems of the Panama Canal and double tracking the Union Pacific half way across the continent, to handling ore for a copper plant in Mexico, but the writer does not feel that an apology is necessary. In all cases the object is the same - rapid and economical transportation. We can not all of us be Goethals nor Harrimans, but we can and should fill to the best of our ability, that particular niche we may be occupying.

Cananea is located in the northern part of the State of Sonora, Republic of Mexico, about 30 miles from the southern border of the United States, and because of the large number of men employed in the plant of the Greene Consolidated Copper Company, is easily the most



NARROW GAGE

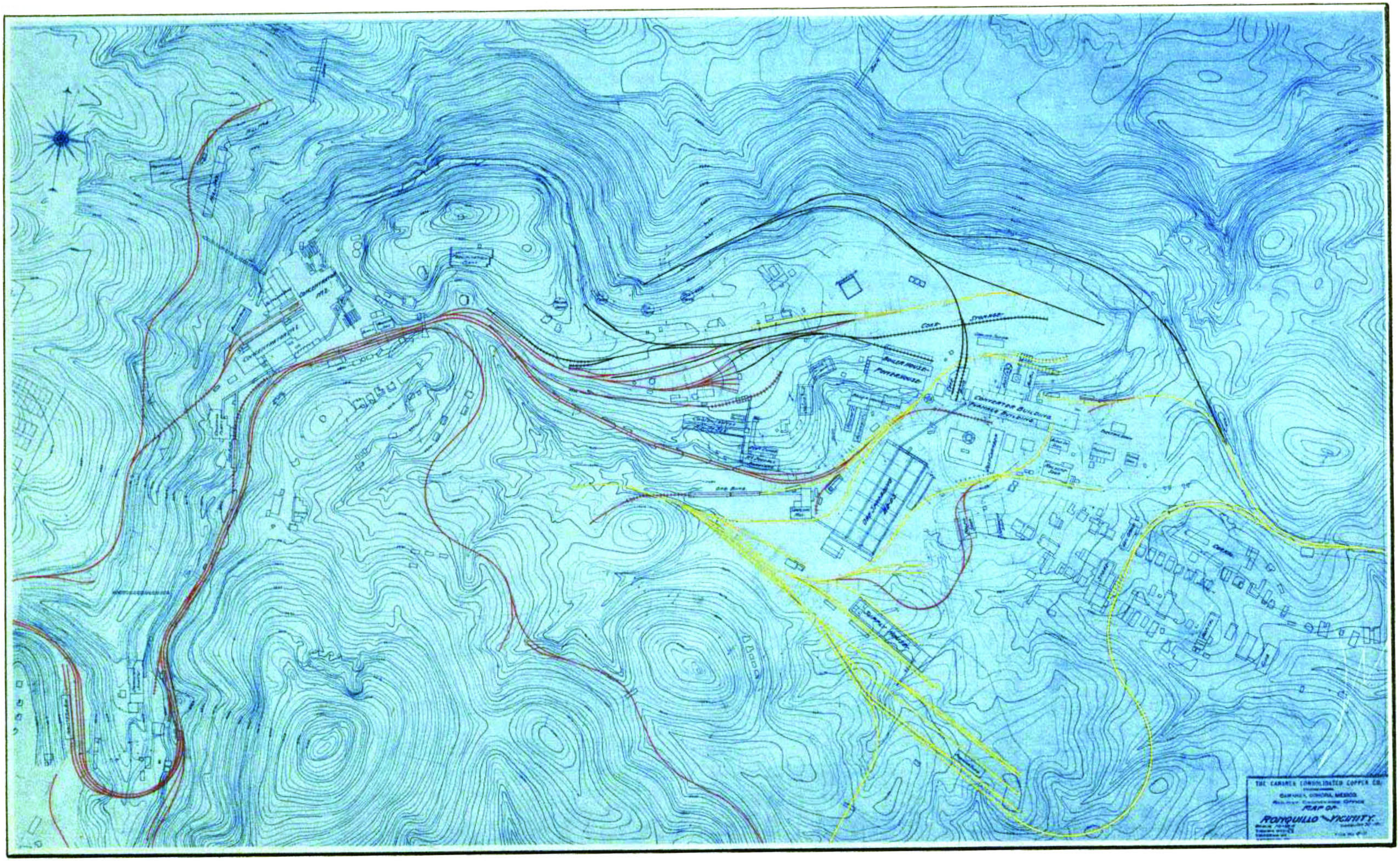
STANDARD GAGE

THREE RAIL

MAP NO. II.

important town in the state. It has a population of 16,000, about 12,000 being Mexicans, the remainder foreigners - nearly all nationalities being represented. Cananea is pleasantly situated in the Cananea Mountains at an elevation of 5300 feet. Communication is had with the outside world by a branch of the Southern Pacific of Mexico which touches the International Line at Naco, Arizona, and a second branch which crosses into the United States at Nogales, Arizona. (See Map No.1 Page 4)

The Reduction Works which consist of ten Mc Dougal furnaces, two reverberatory furnaces, eight blast furnaces and a converting plant are located in the town of Ronquillo, which is really but an extension of the townsite of Cananea (See Map No.2 - Page 6). The Mines are located in the Cananea Mountains proper and between them and the reduction works is a concentrator of 2500 tons daily capacity. The company owns and operates a Standard Gage switching track from the Cananea Yards of the Southern Pacific to the works, warehouses, lumber yards, etc, in Ronquillo. For convenience in switching, a 3rd rail has been laid on most of these tracks, which are partially shown on Map No.3, Page 8. The operating costs of the Standard Gage are seperate from those of the Narrow Gage Division, and as they have no bearing on the cost of hauling ore, no further reference will be made to



CONCENTRATOR & REDUCTION WORKS & SHOWING NARROW GAGE, STANDARD GAGE & THREE RAIL TRACKS.

NARROW GAGE — STANDARD GAGE — 3 RAIL TRACKS.

SCALE ~ 1" = 600'.

MAP NO. III.

them.

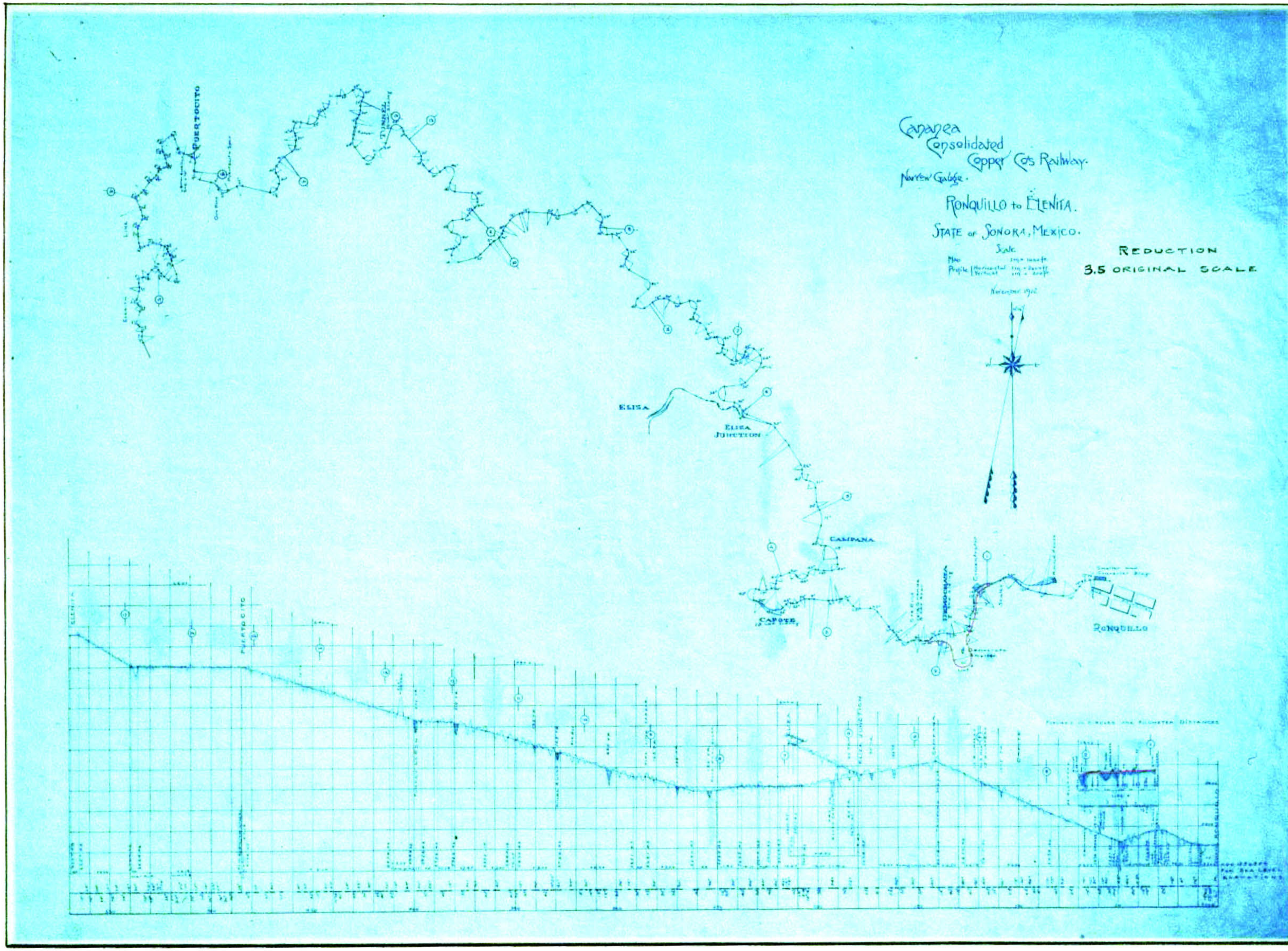
The Narrow Gage Division properly originates at the Smelter and extends to all the principal mines, either via what is termed main line to Puertecito or by seperate spurs or branches as may be seen by further reference to Map No.2, Page 6. In order to accomodate mines that are being constantly developed, additional spurs have been built and the annually increasing mileage is shown herewith:

Year	Narrow Gage Kilometers	Standard Gage Kilometers	Three Rail Kilometers	Total Kilometers
1903	20.93	4.95		25.88
1904	23.60	5.10		28.70
1905	25.99	5.13	2.05	33.17
1906	27.93	3.84	5.12	36.89
1907	35.05	3.53	10.27	48.85
1908	31.45	3.90	15.57	50.92
1909	31.46	3.95	15.59	51.00
1910	32.08	3.79	15.96	51.83

Increase of mileage in 1910 over mileage in 1903 - 100.3%

Note: In cases where the mileage of Narrow Gage or Standard Gage is less in one year than in the preceeding one, it will be noticed that the track has been changed from narrow gage or standard gage to three rail.

In 1902 only that portion from Ronquillo to Puertecito had been built, and it offers as striking an illustration of a fearfully located railroad as the writer has been priveliged to see. The gage is 36" and it was originally built with maximum degree of curve of 54 degrees, American system; 4.75 % grades uncompensated for curvature with loads, and 4% compensated adverse grades.



MAP & CONDENSED PROFILE — NARROW GAGE DIVISION SHOWING ELIMINATION OF 4% ADVERSE GRADE
AUGUST, 1903.

MAP No. IV.

No attempt had been made to develop the line, but the grade of the cañon was followed. After strenously climbing to Campana Saddle by means of this maximum 4.75% grade and 40 degree curves uncompensated, the elevation thus attained was immediately thrown away, as the line now drops down on a 2% compensated grade (Map 4, Page 10). Then follows a series of running down hill on this maximum 2% compensated grade and then climbing out on a maximum 3.3% grade. All these gymnastics were done, notwithstanding that a 2% compensated line with no adverse grades could have been built from Campana Saddle to Puertecito for the same or less expenditure.

In addition to the excessive cost of operating a line thus located, railroad ties of native timber, 35 pound rail without tie plates and clay for ballast formed the roadbed, and the bridges were built of native poles, so that the cost of maintenance was abnormally high as well. The ore bins were of the square bottom type with but two small gates per pocket, so that with some classes of ores, hours were required to load a train. The rolling stock consisted largely of castoffs from a Narrow Gage Line in Arizona that had been changed to Standard Gage, so that the cost of upkeep was large; the type of ore dump cars was obsolete, it often requiring as long to dump a train as it did to load it. The motive power was inadequate, as there were neither enough locomotives to do the work, nor were they heavy enough to handle anything but a small tonnage on the grades of the road.

A study of the problem showed that it would be impossible to eliminate any appreciable percentage of sharp curves and steep grades without practically abandoning the entire constructed line, which was not to be considered; consequently the following plan of attack was adopted, which is herewith subdivided and named according to importance.

1 - Elimination of 4% Adverse Grade at Democrata,

2 - Improvement in Roadbed,

3 - Heavier Motive Power,

4 - Heavier and Improved Type of Rolling Stock,

5 - Improved Type of Ore Bins,

6 - Miscellaneous,

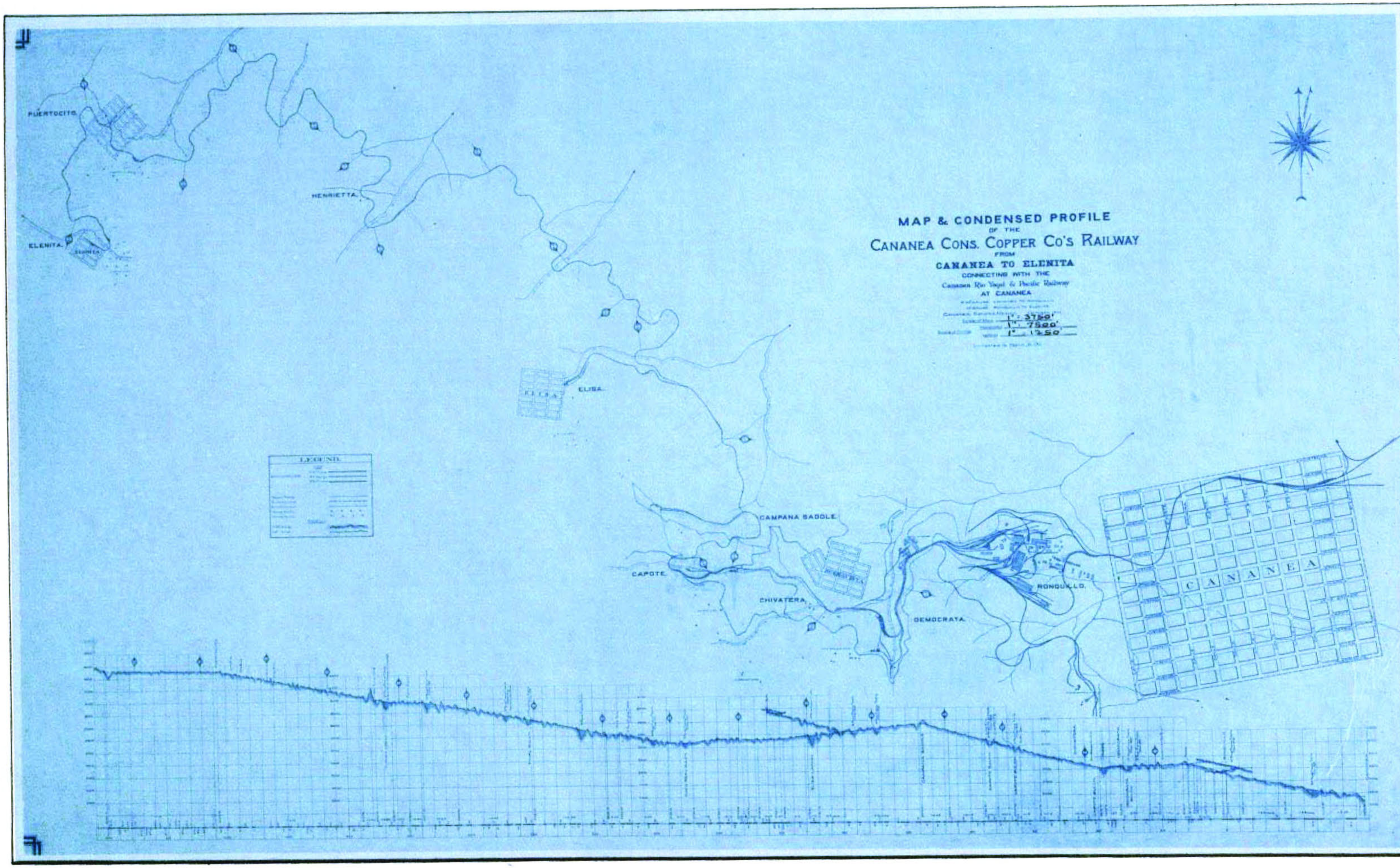
a Reduction of Degree of Curve to 40 Degrees,

b Double Track from Concentrator to Buena Vista,

c Safe Guards for Handling Heavily Loaded Ore Trains Descending Steep Grades,

d Cheaper Labor,

e Oil for Fuel,



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Map & Condensed Profile – After Elimination of 4% Adverse Grade.

Map No V.

Elimination of 4% Adverse Grade at Democrata

By this change, 2650 feet of old line with 4% grades and 40 degree curves was abandoned, Map #4 - Page 10, and 3820 feet of new line with maximum 26 degree curves and 2% and 0.6% adverse grades was built. The 2% adverse grade is at the junction of the new line with the old and as the original line begins to rise immediately on a 4% it should not be considered that this 2% adverse is the ruling grade, but rather the 0.6%, as the ore trains in descending the hill obtain sufficient momentum to easily carry them over the less than 1000 feet of 2% grade (See Map No.5, Page 13) In fact, as will be discussed later, one of the most important items in the operation of this mountain road is to keep the trains from acquiring too great momentum in descending the hill.

It might seem that the introduction of the 2% adverse grade in this change might be criticized but it was so located for the following reasons:

1st The capacities of the locomotives are not reduced thereby, for the reasons mentioned above.

2nd- A considerable saving in first cost was effected by this location.

3rd- As the main ore bins of the camp were to be located at a suitable point on this change of line it was advisable to have as much level track as possible for yard room.

The heaviest locomotive at that time weighed 43.05 tons with 31.45 tons on the drivers. The most an engine of this type could handle over the old line was three cars of ore (See Plate No.9 - Page 20). After the change of line was completed the ore tonnage capacity of a locomotive is measured by the number of empty cars an engine is capable of pushing up the hill to the mines, or as it developed in actual operation, an increase of from three cars to six cars, with the motive power of that time, thus increasing the ore tonnage 100% per trip.

At that time 1903, the cost of operating an engine for 10 hours was as follows:

Engineer,	$ 5.00	
Conductor,	4.25	
Brakeman,	3.50	
Fireman,	3.50	
Coal-2.5 tons @ $8.00,	20.00	
Oil, Tallow and Waste,	.04	
Repairs ($1.00 per Eng Hour),	10.00	
Depreciation-10% on $7400.00,	2.03	
Interest-6% on $7400.00,	1.32	
		$49.54

Or $4.95 per Engine Hour,

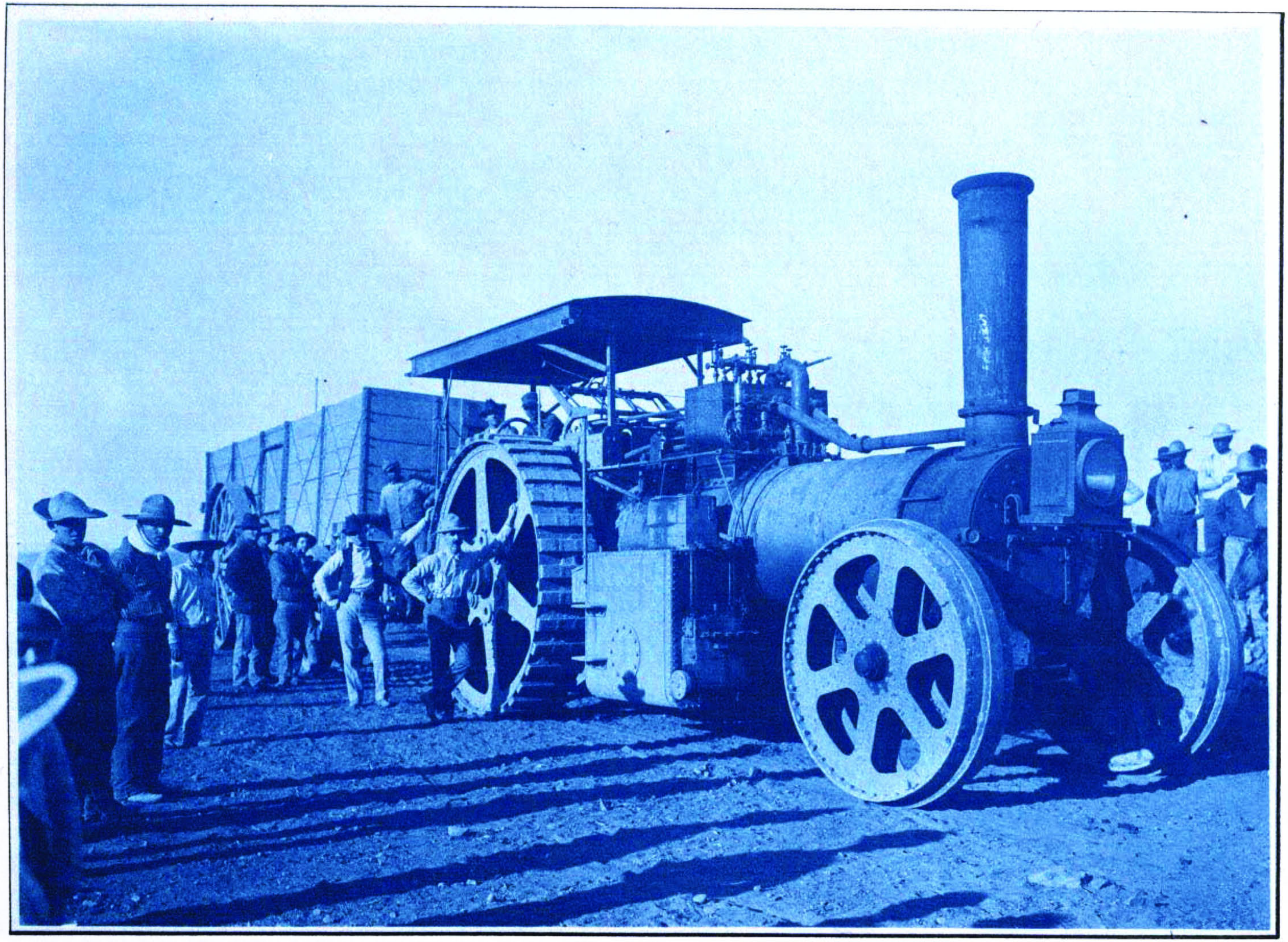
The cost of the change of line was $29000.00, and as has been shown, the saving effected was 100% per locomotive, or as the saving is $4.954 per engine hour, a single locomotive working 5854 engine hours would pay back the cost of the investment, or on the basis of a single locomotive working 10 hours daily, the investment would pay for itself in one year and seven months, or about 60% interest. The change of line was ready for operation in August 1903. The cost of hauling ore for the fiscal year ending December 31, 1903 was 20 cents per ton; for the fiscal year ending December 31, 1904 it was 15.5 cents, a saving of 4.5 cents per ton or $29970.00 for the 666000 tons of ore hauled during the year. This does not indicate however that the investment paid for itself during that year, as other means of reducing cost had been introduced, but it proves that the saving which was predicted was real and not imaginary.

Evolution in Transportation at Cananea - I.
Freighting with Oxen - 1900.

Plate No. VI

EVOLUTION IN TRANSPORTATION AT CANANEA- II.
FREIGHTING WITH HORSES — 1901.

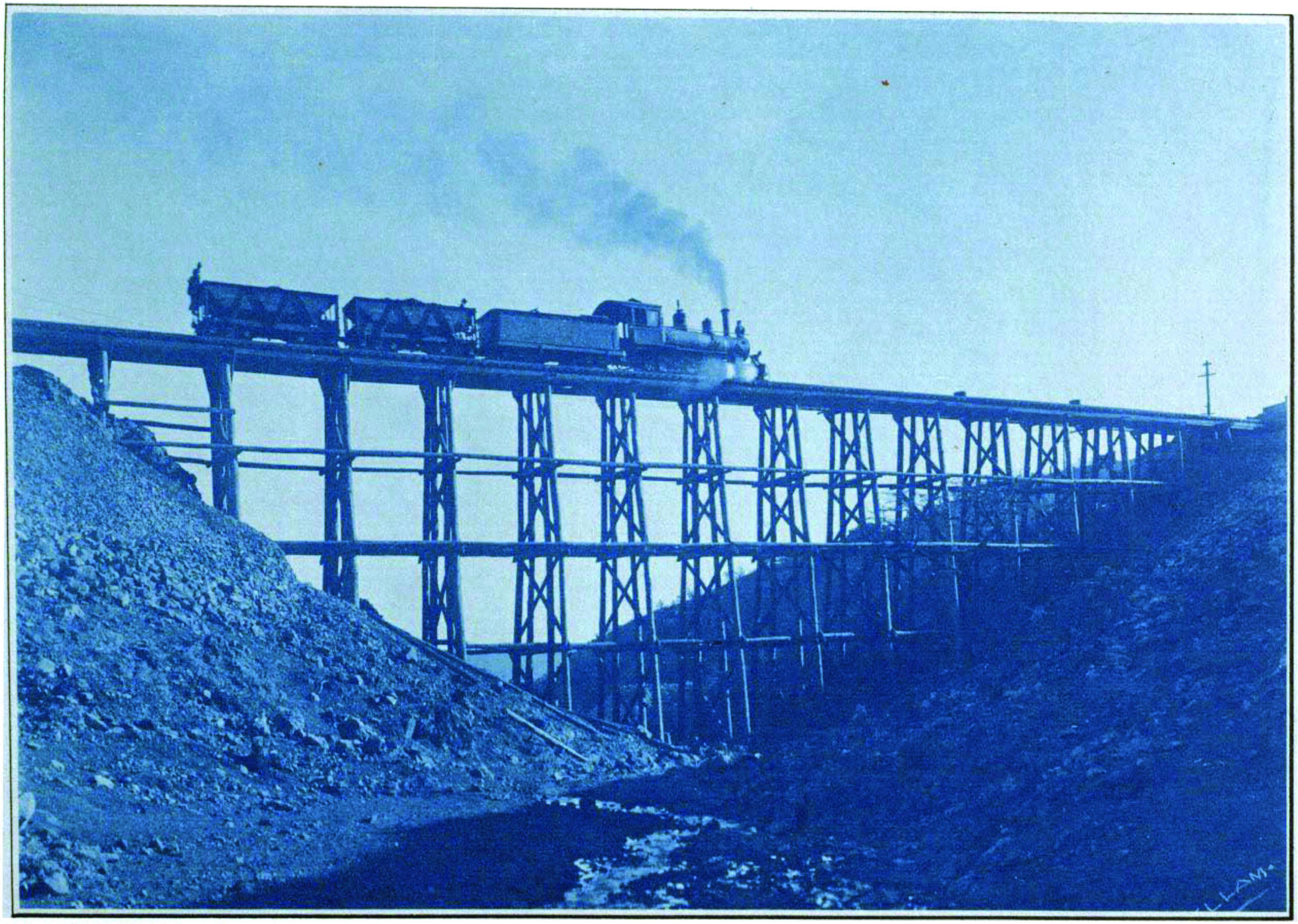
PLATE NO. VII.



EVOLUTION IN TRANSPORTATION AT CANANEA - III.

FREIGHTING WITH TRACTION ENGINE - 1902.

PLATE No. VIII



EVOLUTION IN TRANSPORTATION AT CANANEA – IV.

HAULING ORE – 40 TONS PER TRIP – WITH ENGINE NO. 5 OVER 4% ADVERSE GRADE – 1903

PLATE NO. IX.

EVOLUTION IN TRANSPORTATION AT CANANEA – V.

HAULING 12 CARS OF ORE – 360 TONS – WITH ENGINE NO. 9 IN 1910.

PLATE No X.

Improvement in Roadbed

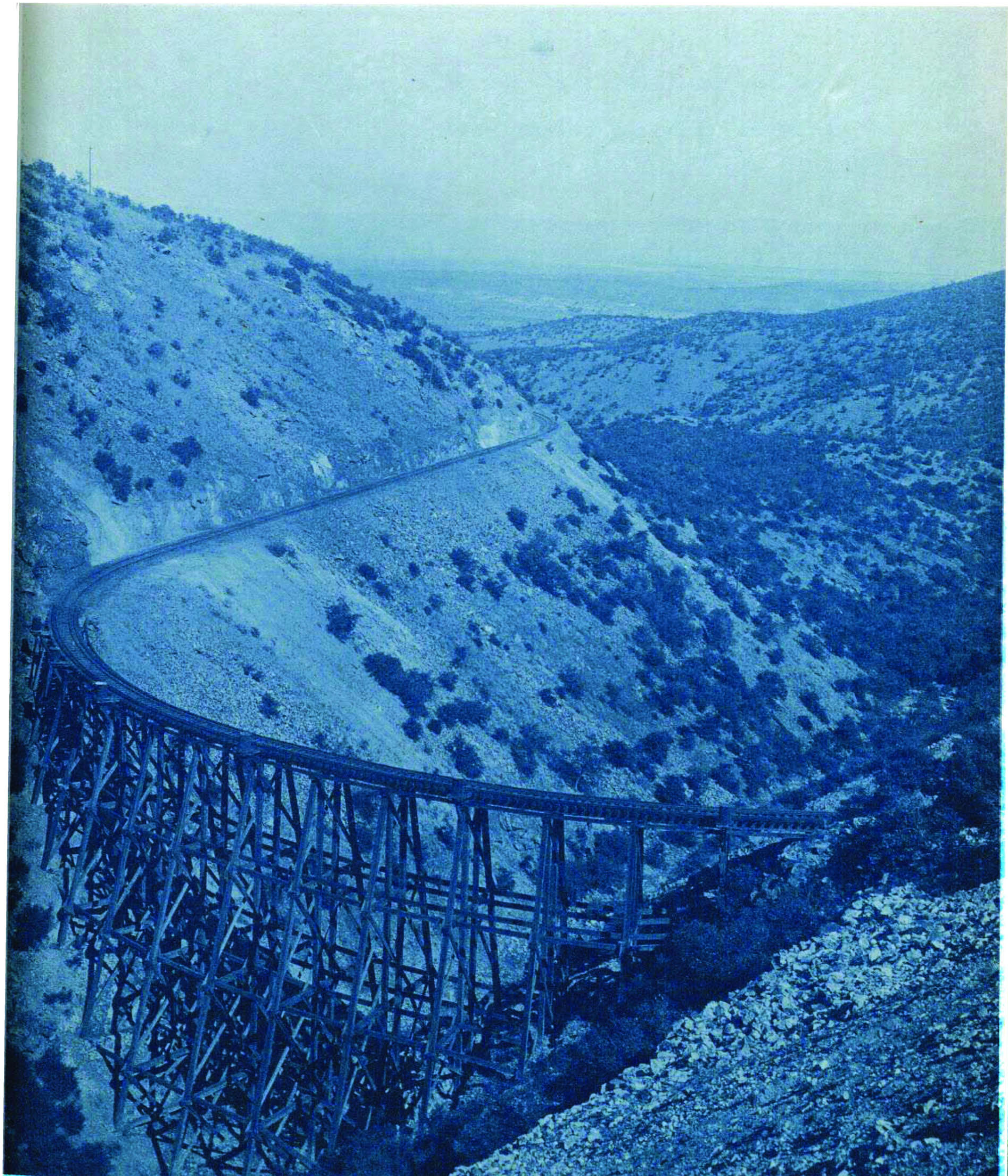
As previously mentioned the track was laid with hewn native pine ties, 35# rail without tie plates and ballasted with clay. The bridges were built with native poles for posts and sawed native timber for caps, sills, girders, ties and stringers - all of pine. It is obvious that the maintenance of such construction is bound to be high. The native timber proved to be of very poor quality, the ties rotting so badly as to require renewals about every two years. The spikes would not hold in the soft wood so that it was difficult to keep the rails from spreading, especially on the sharp curves, thus causing numerous wrecks. The 35# rail which had been in use for many years on another road was badly worn on the ball and broken rails were frequent, further, being of such light section, it was difficult to keep the track in line and surface. The clay ballast did not permit of good drainage of the roadbed, so that after every rain, mud and water would ooze out from under the ties.

It was not possible to correct all these faults of construction at once; but first, tie plates for the 35# rail were procured and applied on the curves and then on the tangents as fast as possible. The clay ballast was dug out and replaced with cinders from the power house and the native ties were replaced with Texas Pine and

California Redwood ties. Then followed relaying of the old 35# rail with 40# rail, this later was relaid with 50# and finally on the sections of the heaviest traffic, this was relaid with 65# rail. The work of relaying fortunately was accelerated on account of the mines needing the old rails for their underground track system. All new tracks were laid with the 50# or 65# rail, tie plates and redwood or Texas Pine ties, and ballasted with cinders.

In 1907 a concession for the importation of fuel oil free from duty was obtained from the Mexican Government by the company, and after oil replaced coal for fuel, slag from the blast furnaces was used for ballast in place of cinders. This slag makes an excellent ballast, although the cost of quarrying it is high, and being very heavy is not as easily handled by the section men as other material. Once however the track is ballasted with this material it needs but little further attention. Water quickly drains off the roadbed and it has been the experience here that ties rot less quickly with slag ballast than with cinders.

In the line built prior to 1903, and in the spurs built since, there were 37 bridges requiring 1,830,000 F.B.M. of timber in their construction. Early the policy of filling bridges was adopted and to date 30 of these have been filled requiring 255,000 cubic yards of embankment. Most of the bridges have been filled were of



ELISA CAÑON BRIDGE ON 34° CURVE.
TYPE OF LATER DAY CONSTRUCTION.

PLATE No XI.

the native timber construction, where it was a question of rebuilding the bridge or making the fill. Mine waste is the material largely used for this filling, but in most cases, if the bridge was loeated so as to require the hauling of waste up-grade, the bridge was filled from a near borrow. These trestles that have been filled required 1, 250,000 f.b.m. in their construction; to renew these bridges at $50.00 per m erected, would cost $62,500.00, while the cost of filling them at an average of 15 cts per cubic yard was $38,250.00, representing a saving of $24,250.00. In addition to this, their annual cost of maintenance has been entirely eliminated, as well as the danger of serious wrecks at these points, and, further, the possibility of the line being tied up because of a burned bridge, has been almost entirely removed.

The maintenance of any track requires constant and careful attention, but more especially is this true of a mountain road with the grades and curves of the one under discussion. The writer has devoted much care to this phase of the problem, and as it has been several years since any accident of consequence due to bad track has happened, the writer feels that the care and attention given the maintenance of the track has not been without success. Good drainage of the roadbed by the use of surface and side ditches, and ample drain boxes, the adoption of 50# and 65# A.S.C.E. rail section as standard, the use of redwood ties and tie plates, slag for ballast, the filling of bridges and the employment of efficient section foremen have been the means whereby the improvement in roadbed has been attained.

FILLING TRESTLE WITH MINE WASTE WITH TRAIN OF INGOLDSBY CARS DUMPING OVER 45' APRON TO PROTECT BOTTOM POSTS, GIRDERS AND BRACES.

PLATE No. XII

Heavier Motive Power

(See characteristics of locomotives - Pages 28-31 Inc)

Because of the sharp curves, heavy grades and relatively short haul, a particular design of locomotive was called for which is known as Double End Saddle Tank, or Side Tank, Locomotive. All of the narrow gage engines are of this type, although Engine #5 when bought second hand from the A & N.M. Ry. of Arizona was a Mogul with a tender (See Plate No.9 - Page 20), but was changed to the standard type in 1905. With this type of engine no tender is required as the water is carried in a saddle tank or side tanks over the boilers and the coal bunker is built over the back trucks, so that the greatest possible weight on the drivers is obtained, and at the same time no energy is expended in hauling a heavy tender up 4.5% grades and around 40 degree curves. The driving wheel base is limited to nine feet so that the engines curve easily and are further assisted by a swinging bolster truck front and back, which guides the drivers on the sharp curves equally well running forward or backward. It will be readily seen that with the weight of the drivers on such a short driving base, the track and bridges must be well maintained.

After the track had been dug out of the mud, and the 35# rail had been relaid with heavier steel, the

CHARACTERISTICS OF LOCOMOTIVES. C.C.C.CO'S RY.

March 1909.

No.	Gage.	Type.	Maker.	Shop No.	Cost: Amount.	Cost: Place.	Entered Service.	Cylinders.	Drivers: No.	Drivers: Dia.	Wheel Base: Engine.	Wheel Base: Driving.	Wheel Base: Eng. & Tender.	No.
1.	36"	Double Ender-6 whls connected-2 Side Tanks. 2 whl. swig. bolster truck-f & b.	H.K. Porter Co.	2348.	$6183.27	Pittsburg.	Sept-1901.	12"x18.	6.	36."	19'-4."	8'-0."		1.
2.	36"	" " " " " "	" "	2349.	" "	" "	" "	"	"	"	"	"		2.
3.	36"	Double Ender. 6 whls connected-2 Side Tanks. 2 whl. swig. bolster truck-f & b.	Baldwin Loc. Works.	20486.	$7371.00	" "	July-1902.	14"x16.	6.	34."	21'-4."	8'-6."		3.
4.	36"	" " " " " "	" "	20487.	" "	" "	" "	" "	"	"	"	"		4.
5.	36"	Double Ender. 6 whls connected-2 Side Tanks. 2 whl. swig. bolster truck-f & b.	" "	17363.	$6350.00	Of A.& N.M. Ry. Morenci.	March-1902.	14"x22.	6.	44."	16'-4."	9'-8."		5.
6.	36"	Double Ender. 6 whls connected-Saddle Tank. 2 whl. swig. bolster truck-f & b.	H.K. Porter Co.	2967.	$8775.00 $9309.73	Pittsburg. Cananea.	March-1904.	15"x20."	6."	38."	22'-8."	9'-1."		6.
7.	36"	" " " " " "	American Loc. Works.	30317.	$9968.00 $10897.00	Schenectady. Cananea.	Feb-1905.	15"x20."	6.	36."	23'-3	9'-0."		7.
8.	36"	" " " " " "	" "	29719.	$9550.00 $10286.14	Dickson. Cananea.	Aug-1906.	16"x20."	6.	36."	23'-3."	9'-0."		8.
9.	36"	" " " "	Baldwin Loc. Works.	35028.	$9850.00 $11014.43	Philadelphia. Cananea.	Dec-1910.	17"x20."	6.	38."	24'-4."	9'-0."		9.
11.	4'-8½"	10 Wheeler-6 wheels connected. Tender-8 wheels.	Baldwin Loc. Works	19912.	$13151.37	Naco.	March-1902.	20"x26.	6.	54."	23'-11."	14'-0."	50'-0."	11.
12.	4'-8½"	Double Ender. 6 whls connected. Saddle Tank. 2 whl. swig. bolster truck-f & b.	"	31854.	$10260.00 $11091.70	Philadelphia. Cananea.	Dec. 1907.	18"x24."	6.	44."	24'-0."	9'-0."		12.

PLATE No. XIII.

CHARACTERISTICS OF LOCOMOTIVES. C.C.C.CO'S RY. CONT'D.

No.	Engine Trucks. Kind.	Engine Trucks. Dia. Whls.	Tank Trucks. ℄ To ℄.	Tank Trucks. Whl. Base	Tank Trucks. Dia. Whls.	Length. Over P.B.	Length. Over All.	Width. Over P.B.	Width. Over All	Height. To Coupler	Height. To Cab't Side	Height. Water Intake	Height. Top Stack	Capacity. Water Gals.	Capacity. Coal Tons.	Capacity. Oil Gall's.	No.
1.	2 wheel Swivel beam.	20"				24'-11"	28'-10"	8'-1"	8'-5"	26"	9'-2½"	10'-0"	11'-3"	721.	2.1.		1.
2.	" " "	"				"	"	"	"	"	"	"	"	"	"		2.
3.	" " "	24"				25'-5"	29'-8"	8'-9"	8'-9"	26"	9'-8"	11'-3½"	11'-8"	1200.	1.74.	729.	3.
4.	" " "	"				"	"	"	"	"	"	"	"	"	"	734.	4.
5.	" " "	28"				24'-8"	25'-9"	6'-11"	8'-7½"	27"	10'-5"	11'-0"	11'-7"	1050	1.4.	566.	5.
6.	" " "	24"				28'-2¼"	32'-9"	7'-2"	9'-6"	26"	10'-2"	10'-1"	11'-3½"	1100.	2.7.	765.	6.
7.	Radial Swing.	24"				29'-11½"	34'-1"	9'-2"	9'-9"	26½"	10'-0"	9'-11"	11'-3½"	1200	2.5	790.	7.
8.	" "	24"				29'-10½"	34'-2"	9'-2½"	9'-11"	27½"	10'-0"	10'-0"	11'-3½"	1400		931.	8.
9.	Swinging Bolster.	26"				30'-10"	35'-10"	9'-2¼"	10'-1½"	26½"	10'-7¾"	10'-3½"	12'-6¾"	2000		622.	9.
11.	4 Wheel.	34"	10'-5"	5'-3"	34"	56'-7"	59'-5"	9'-10"	10'-2"	31"	12'-4"	9'-9"	15'-2"	4400		1320.	11.
12.	2 wheel Swivel Beam.	28"				30'-7"	34'-3½"	9'-10½"	10'-8½"	30½"	10'-9½"	12'-0"	14'-3½"	2500.		831.	12.

20-B-6.

PLATE No XIV.

CHARACTERISTICS OF LOCOMOTIVES. C.C.C.Co's RY. CONT'D. March 1909.

No	Boiler: Type	Boiler: Dia.	Boiler: Pres.	Fire Box.	Flues: Number	Flues: Diameter	Flues: Length	Heating Surface Sq. Ft.: Tubes	Heating Surface Sq. Ft.: Fire Box	Heating Surface Sq. Ft.: Total	Grate Area Square Feet	Head Lights.	Injectors.	Lubricators.	Air Pump: Kind.	Air Pump: Size.	Air Pump: Pressure	Sanders	No.
1	Wagon Top	37 3/4" 44"	150#	54x24"	83	2"	7'-6"					Oil	2-No. 5 Monitor	Old Style. Detroit.	Wstinghse.	9 1/2"	110.#	Leach Air.	1.
2	" "	"	"	" "	"	"	"					"	" "	" "	"	"	"	"	2.
3	Straight Top.	50"	160#	66 3/16 x 24"	171	1 3/4"	9'-0"	698.5	66.2	764.7	11.	Acetylene.	" "	" "	"	9 1/2"	110.#	"	3.
4.	" "	"	"	" "	"	"	"	"	"	"	"	"	" "	No. 9 Detroit. Bull's Eye	"	"	"	"	4.
5.	" "	44"	160#	72 11/16 x 24 3/8"	142	1 3/4"	8'-10"	569.2	71.6	640.8	12.5	"	" "	Old Style Detroit	"	9 1/2"	110#	"	5.
6.		54" 56"	160#	80"x24 1/2"x46 1/4	164.	2"	9'-0	767.5				"	2-No. 7 Monitor.	No. 9 Detroit. Bull's Eye.	"	9 1/2"	110#	"	6.
7.	" "	52" 53"	180#	46 1/4"x44 1/2"	168.	2"	13'-2	1151	69.	1220.	14.23	Pyle Electric. Front & Back.	" "	" "	"	9 1/2"	110.#	"	7.
8.		54" 55"	175#	46 1/4x44 1/4"	180.	2"	13'-2	1233	66.	1299	14.2	"	" "	" "	"	9 1/2"	110.#	"	8.
9.	" "	58"	190#	87 15/16x 24"	190.	2"	10'-4	1019.	105.	1124	14.6.	"	" "	No. 21 Detroit. Triple Bullseye.	"	9 1/2"	110#	"	9
11	Wagon Top.	64"	180.#	108 1/8"x32"	291.	2"	13'-0.	1968.	174.7	2142.7	24.8	Acetylene.	2-No. 9 Monitor.	" "	"	9 1/2"	110.#	"	11.
12	Straight Top	62"	180#	76 11/16"x41 1/8"	244	2"	10'-8"	1363.	111.4	1477	22.	Pyle-Electric Front & Back.	2-No. 8 Monitor.	" "	"	9 1/2"	110.#	"	12.

PLATE No. XV.

CHARACTERISTICS OF LOCOMOTIVES. C.C.C.CO'S RY. CON'TD.

No	Weight in Tons. Engine	Weight in Tons. Drivers	Weight in Tons. Eng & Ten	Maximum Tractive Power-Lbs.	Factor of Adhesion	Tractive Force-Tons 1%	2%	3%	4%	5%	6%	Remarks	No
1.	30.0	22.5		9180.	4.90	183.	113	78	56	42.	32.		1.
2.	"	"		"	"	"	"	"	"	"			2.
3.	43.05	31.45		12544.	5.01	248.	152	104.	75.	55.	42.	Equipped with 1-No 7 Hammell Oil Burner Oct 29-1909.	3.
4.	"	"		"	"	"	"	"	"	"		Equipped with 1-No 7 Hammell Oil Burner Mch-27-1909.	4.
												No 5-Equipped with 1-No 7 Hammell Oil Burner:-Jun 5-1910	5.
5.	40.05	31.0		13328.	4.63	269.	168	116	85.	65.	50.	Engine was Mogul when bought from A. & N. M. Ry. Changed to Double Ender with Side Tanks 8-15-05 [illegible] Truck. Back Truck added March 1908.	5.
6.	50.0	41.0		16136.	5.08	324.	201.	139.	102.	77.	59.	Equipped with 2-No 7 Hammell Oil Burners. June 2-1909.	6.
7.	52.0	40.0		19125.	4.16	391.	246.	172.	128.	98.	77.	Equipped with 1-No 7 Hammell Oil Burner July 19-1909.	7.
8.	57.6	47.0		21155.	4.44	432.	271.	190.	141.	108.	85.	Equipped with 1-No 7 Hammel Oil Burner. Jan 10-1909.	8.
9.	64.25	50.0		24500.	4.08.	504.	317.	223.	166.	128.	101.	Equipped with 2-No 7 Hammel Oil Burners. Dec 5-1910.	9.
11.	70.0	55.0	115.0	29467.	3.73	733.	413.	268.	186.	133.	95.	Equipped with 2-No 7 Hammel Oil Burners. Oct 12-1908.	11.
12.	74.0	60.0		27040.	4.44	704.	411.	278.	202.	153.	119.	" " " " " " " Feb 27-1909.	12.

Approved. V. R. Stelling
Superintendent of Railways.

20-B-7

PLATE No. XVI.

railroad was in a position to make a profitable investment by the purchase of heavier motive power. It has been shown that by building a certain change of line, a locomotive can do 100% more work and pay for the investment in the incredible short period of one year and seven months, and it is now to be shown that it is good business to scrap light engines costing $6700.00 each and spend 50% to 75% more in the purchase of heavier motive power (See Plates No. 17 & 18 - Page 33).

By reference to the Characteristics of Locomotives it will be seen that the first investment of this nature was made in 1904 by the purchase of a locomotive with 41 tons on the drivers; this was followed the next year by the purchase of Engine No.7 with approximately the same weight on the drivers but with greater tractive force. Because of better track conditions, Engine #8 with still greater tractive power and 47 tons on the drivers was purchased in 1906, and the limit of heavy motive power, on account of clearances of ore bins, overhead bridges and tunnels, has practically been reached with the delivery of Engine No.9 in 1910 - ordered in 1907 but delivery cancelled on account of panic - with tractive power of 25000 pounds and 50 tons weight on the drivers (See Plate No.18 - Page 33).

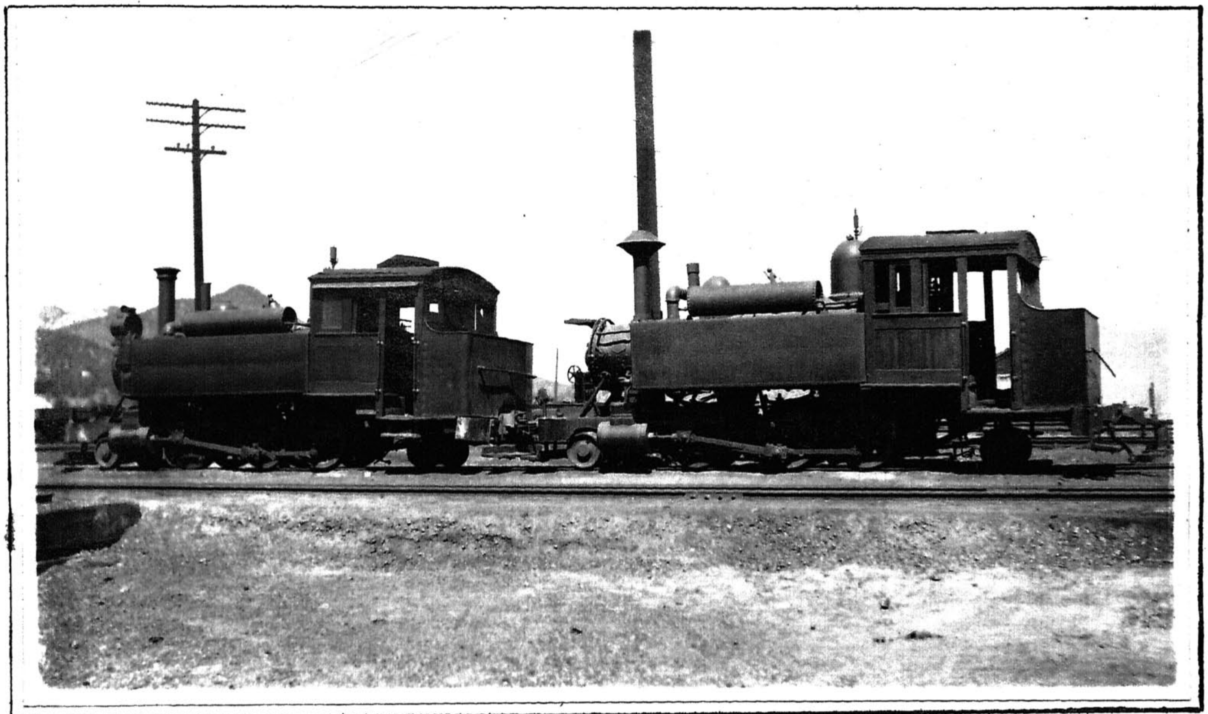


PLATE No. XVII.

ENGINES 1 & 2 IN BONE YARD
WEIGHT ON DRIVERS 22.5 TONS. TRACTIVE POWER 9180#

PLATE No. XVIII.

ENGINE No. 9 - HEAVIEST TYPE OF NARROW GAGE LOCOMOTIVE.
WEIGHT ON DRIVERS 50 TONS. TRACTIVE POWER 24500 LBS.

For the purpose of proving that a creditable saving can be made by the purchase of heavier motive power, a comparison of the costs of operating Engine No.1 and Engine No.9, together with a statement of the work each is capable of performing, is shown herewith.

Cost of Operating Engine No.1 per day of 10 hours

Engineer,	$5.00	
Conductor,	4.25	
Brakeman,	3 50	
Fireman,	3.50	
Coal - 2 tons @ $8.00,	16.00	
Repairs - $1.00 per Engine hour,	10.00	
OIl, Tallow & Waste,	.04	
Depreciation - 10% on $6700.00,	1.84	
Interest - 6% on $6700.00,	1.10	$45.23

or $4.52 per engine hour.

Cost of Operating Engine No.9 per day of 10 hours

Engineer,	$ 5.00	
Conductor,	4.25	
Brakeman,	3.50	
Fireman,	3.50	
Coal - 3.75 tons @ $8.00,	30.00	
Repairs - $1.20 per Engine Hour,	12.00	
Oil, Tallow & Waste,	.05	
Depreciation - 10% on $11000.00,	3.02	
Interest - 6% on $11000.00,	1.81	65.13

or $6.51 per engine hour.

In making the comparison of the work each engine is capable of performing, the hauling of ore from the Capote Ore Bins to the Smelter will be used as the basis.

The average time per round trip is one hour; the average time of loading one car is two minutes and the average time of unloading is one minute - based on improved type of bins and cars. Engine No.1 will handle six cars per trip and Engine No.9 will handle twelve cars (See Plate No.10 - Page 21) so that the calculation is as follows:

Engine No.1:

6 trips hauling 36 cars,	6 hours
Loading & Unloading 36 cars @ 3 min ea,	1.8 "
Total,	7.8 "
$4.52 per engine hour X 7.8 hrs,	$35.26
Hauling 36 cars - cost per car,	$ 0.98

Engine No.9:

6 trips hauling 72 cars,	6 hours
Loading & Unloading 72 cars @ 3 min ea,	3.6 "
Total,	9.6 "
$6.51 per engine hour x 9.6 hours,	$62.48
Hauling 72 cars - cost per car,	$ 0.87
Saving effected per car,	$ 0.11

In making the comparison of the work each engine is capable of performing, the hauling of ore from the Capote Ore Bins to the Smelter will be used as the basis.

The average time per round trip is one hour; the average time of loading one car is two minutes and the average time of unloading is one minute - based on improved type of bins and cars. Engine No.1 will handle six cars per trip and Engine No.9 will handle twelve cars (See Plate No.10 - Page 21) so that the calculation is as follows:

Engine No.1:

6 trips hauling 36 cars,	6 hours
Loading & Unloading 36 cars @ 3 min ea,	1.8 "
Total,	7.8 "
$4.52 per engine hour X 7.8 hrs,	$35.26
Hauling 36 cars - cost per car,	$ 0.98

Engine No.9:

6 trips hauling 72 cars,	6 hours
Loading & Unloading 72 cars @ 3 min ea,	3.6 "
Total,	9.6 "
$6.51 per engine hour x 9.6 hours,	$62.48
Hauling 72 cars - cost per car,	$ 0.87
Saving effected per car,	$ 0.11

On the basis of hauling 72 cars daily, the daily saving is \$7.92 or \$2890.80 per year which represents 26% interest on the investment.

Following the same line of reasoning, proved the wisdom of purchasing all of the heavier locomotives and the scrapping of Engines No.1 and 2. What has been said of the two lighter engines is likewise trus of locomotives 3, 4 and 5, except that these are still used for reserve engines but the hauling of ore and supplies is done almost entirely by the heavier motive power - Engines No.6, 7, 8 and 9.

Improved Type of Rolling Stock
(See characteristics of cars Pages 38-45 Inc)

At the close of the fiscal year December 31, 1903, the rolling stock consisted of the following equipment:

1	Side Dump Wooden Ore Car,	30000 Cap'y
6	Wooden Hopper Bottom Ore Cars,	40000 "
10	Center Dump Steel Ore Cars,	30000 "
6	" " " " "	60000 "
4	Wooden Flat Cars,	30000 "
2	" " "	35000 "
2	Box Cars,	50000 "
1	Caboose,	
32	Cars Total Equipment	

The rolling stock was entirely insufficient to handle the work at that time, furthermore, with the exception of the sixteen steel ore cars and the two box cars, the equipment was second hand and the cost of upkeep was high. The steel ore cars were well built and were easily kept in repair but their type of dump is not well adapted to all classes of ore and concentrates of this camp and the same is true of the dump arrangement of the Wooden Hopper Bottom Cars. A plan, elevation and section of the steel ore cars are shown on page 47, and a similar drawing of the wooden hopper bottom cars is shown on page 48. By reference to these it will be observed that the dumping space in the former is made up of two openings

CHARACTERISTICS OF CARS ~ C.C.C.CO'S RY.

November 1909

			Type.				Truck.				Length.			Width.			Height.				Capacity.	
Initial	Present Number	Old Number	Gage	Material	Class	Maker	Kind	Journal	Dia. Whl.	Whl. Base	c-c Trucks	Over End Sills	Over All	Inside	Over Side Sills	Over All	Inside	Rail to Coupler	Rail to Floor	Rail to Top	Weight	Cu. Ft.	Lbs.
C.	25.	01.	36"	Wood	Caboose	C.C.C.Co's Railway Shops.	Rigid.	3¾x7"	24"	4'-6"	21'-6"	30'-2"	34'-6"	29'-5"	7'-2"	7'-9"	6'-5"	24"	3'-7"	10'-8"			30,000
.	W.35	84	.	Steel Frame	Wrecking Car.	. .	.	3¾x7"	24"	4'-6"	23'-1½"	28'-3"	30'-9"	15'-8"	7'-6"	7'-4"	6'-10"	27"	3'-2"	10'-1"			60,000
.	75.	51.	.	Wood.	Observation Passenger Car	. .	.	4¼x8"	24"	4'-4"	15'-9½"	26'-8"	29'-10"	24'-10"	7'-7"	7'-8"	6'-11"	26"	3'-8"	11'-6"			30,000
.	76.	52.	.	.	.	. .	.	.	.	.	15'-5"	24'-6"	29'-4"	23'-1"	7'-6"	8'-4½"	6'-11"	.	3'-11"	11'-5"			.
.	100.	210.	.	Wood	Flat Car.	America Car & Fdy Co	.	5"x7"	26"	4'-6"	25'-10½"	32'-6"	34'-6½"		7'-2"	7'-10"		28"	3'-6"	3'-6"	14100.		30,000
.	101.	211.	.	.	.	. .	.	.	.	.	.	.	.		.	.		.	.	.	.		.
.	102.	212.	.	.	.	. .	.	.	.	.	.	.	.		.	.		.	.	.	.		.
.	103.	213.	.	.	.	. .	.	.	.	.	.	.	.		.	.		.	.	.	.		.
.	104.	214.	.	.	.	. .	.	.	.	.	.	.	.		.	.		.	.	.	.		.
.	105.	215.	.	.	.	. .	.	.	.	.	.	.	.		.	.		.	.	.	.		.
.	106.	216.	.	Wood.	Flat Car.	America Car & Fdy Co	.	4"x7"	28"	4'-4"	23'-1"	32'-1"	34'-5"		7'-1"	8'-1"		27"	3'-5½"	3'-5½"	10000.		50,000
.	107.	217.	.	.	.	. .	.	.	.	.	.	.	.		.	.		.	.	.	10000.		.
.	108.	218.	.	.	.	. .	.	.	.	.	.	.	.		.	.		.	.	.	15640.		.
.	109.	219.	.	.	.	. .	.	.	.	.	.	.	.		.	.		.	.	.	15760.		.
.	110.	220.	.	.	.	. .	.	.	.	.	.	.	.		.	.		.	.	.	15900.		.
.	111.	221.	.	.	.	. .	.	.	.	.	.	.	.		.	.		.	.	.	16200.		.
.	150.	101.	.	Wood	Flat Car.	C.C.C.Co's Railway Shops.	.	3¾x6"	26"	4'-6"	15'-4"	24'-6"	26'-11"		7'-0"	7'-5"		27"	3'-2"	3'-2"	11790.		14,000
.	151.	102.	.	.	.	. .	.	3¾x6"	26"	4'-0"	22'-6"	30'-0"	32'-0"		7'-4"	7'-8"		27"	3'-4½"	3'-4½"	12700.		30,000
.	152.	103.	.	.	.	. .	.	3¾x6"	26"	4'-0"	15'-8"	24'-7"	26'-8"		7'-6"	7'-9"		27"	3'-6"	3'-6"	12400.		30,000
.	153.	104.	.	.	.	. .	Swing Beam.	3¾x5"	26"	4'-0"	17'-4"	24'-11"	27'-10"		7'-4"	7'-10½"		26"	3'-4"	3'-4"	10800.		22,000
.	154.	105.	.	.	.	. .	Rigid.	3¾x6"	26"	4'-0"	15'-2"	24'-6"	26'-11"		7'-2"	7'-7"		27½"	3'-6"	3'-6"	12300.		30,000
.	155.	106.	.	.	.	. .	.	3¾x6"	26"	4'-0"	22'-0"	30'-0"	31'-3"		7'-0"	7'-9"		28"	3'-6½"	3'-6½"	13000.		35,000
.	200.	222.	.	Steel.	Flat Car.	Middletown Car Works	.	4¼x8"	26"	4'-6"	23'-0"	34'-0"	36'-0"		7'-10"	6'-9"		27"	3'-2"	3'-2"	17700.		50,000
.	201.	223.	.	.	.	. .	.	.	.	.	.	.	.		.	.		.	.	.	.		.
.	202.	224.	.	.	.	. .	.	.	.	.	.	.	.		.	.		.	.	.	.		.
.	203.	225.	.	.	.	. .	.	.	.	.	.	.	.		.	.		.	.	.	.		.
.	204.	226.	.	.	.	. .	.	.	.	.	.	.	.		.	.		.	.	.	.		.
.	205.	227.	.	.	.	. .	.	.	.	.	.	.	.		.	.		.	.	.	.		.
.	206.		.	.	.	. .	.	.	.	.	.	.	.		.	.		.	.	.	21000.		.
.	207.		.	.	.	. .	.	.	.	.	.	.	.		.	.		.	.	.	.		.
.	208.		.	.	.	. .	.	.	.	.	.	.	.		.	.		.	.	.	.		.

PLATE No. XIX.

CHARACTERISTICS OF CARS ~ C.C.C. CO'S RY. ~ CONT'D.

November 1909

Initial	Present Number	Old Number	Type: Gage	Type: Material	Type: Class	Maker	Truck: Kind	Truck: Journal	Truck: Dia. Whls.	Truck: Whl. Base	Truck: C. to C. Trucks	Length: Over End Sills	Length: Over All	Length: Inside	Width: Over Side Sills	Width: Over All	Width: Inside	Height: Rail to Center	Height: Rail to Floor	Height: Rail to Top	Weight	Capacity: Cu. Ft.	Capacity: Lbs.
Ga	209		36"	Steel	Flat Car	Middletown Car Works	Rigid	4½ x 8	24"	4'-4"	23'-0"	34'-6"	36'-6"		7'-11"	8'-6"		27"	3'-8"	3'-2"	20000		50000
"	210		"	"	"	"	"	"	"	"	"	"	"		"	"		"	"	"	"		"
"	211		"	"	"	"	"	"	"	"	"	"	"		"	"		"	"	"	"		"
"	212		"	"	"	"	"	"	"	"	"	"	"		"	"		"	"	"	"		"
"	213		"	"	"	"	"	"	"	"	"	"	"		"	"		"	"	"	"		"
"	214		"	"	"	"	"	"	"	"	"	"	"		"	"		"	"	"	"		"
"	215		"	"	"	"	"	"	"	"	"	"	"		"	"		"	"	"	"		"
"	216		"	"	"	"	"	"	"	"	"	"	"		"	"		"	"	"	"		"
"	217		"	"	"	"	"	"	"	"	"	"	"		"	"		"	"	"	"		"
"	218		"	"	"	"	"	"	"	"	"	"	"		"	"		"	"	"	"		"
"	219		"	"	"	"	"	"	"	"	"	"	"		"	"		"	"	"	"		"
"	220		"	"	"	"	"	"	"	"	"	"	"		"	"		"	"	"	"		"
"	250	107	"	"	"	C.C.C. Co's Railway Shops	"	4½ x 8	24"	4'-4"	17'-6"	28'-5"	30'-2"		7'-6"	7'-8"		26"	3'-7"	3'-2"	16100		60000
"	300	300	"	Wood	Double Hopper Bottom	American Car & Fdy Co.	"	4¼ x 7	26"	4'-6"	18'-10"	30'-1"	33'-6"		6'-10"	7'-9"		26"		8'-1"	25200	498	[illegible]
"	301	301	"	"	"	"	"	"	"	"	"	"	"		"	"		"	"	"	25330	511	"
"	302	302	"	"	"	"	"	"	"	"	"	"	"		"	"		"	"	"	25950	507	"
"	303	303	"	"	"	"	"	"	"	"	"	"	"		"	"		"	"	"	25730	498	"
"	304	304	"	"	"	"	"	"	"	"	"	"	"		"	"		"	"	"	26330	510	"
"	305	305	"	"	"	"	"	"	"	"	"	"	"		"	"		"	"	"	25670	507	"
"	400	400	"	Wood	Ingoldsby Auto Dump	Mount Vernon Car Co.	"	4¼ x 8	26"	4'-5"	27'-0"	35'-1"	37'-6"		7'-8"	8'-5"		28"	3'-9"	7'-2"	27300	633	50000
"	401	401	"	"	"	"	"	"	"	"	"	"	"		"	"		"	"	"	"	"	"
"	402	402	"	Steel	Ingoldsby Auto Dump	Mount Vernon Car Co.	"	4½ x 8	24"	4'-4"	17'-3"	24'-1"	25'-10"		7'-1"	7'-11"		27"		7'-11"	20650	453	60000
"	403	403	"	"	"	"	"	"	"	"	"	"	"		"	"		"	"	"	20950	"	"
"	404	404	"	"	"	"	"	"	"	"	"	"	"		"	"		"	"	"	21160	"	"
"	405	405	"	"	"	"	"	"	"	"	"	"	"		"	"		"	"	"	20960	"	"
"	406	406	"	"	"	"	"	"	"	"	"	"	"		"	"		"	"	"	20680	"	"
"	407	407	"	"	"	"	"	"	"	"	"	"	"		"	"		"	"	"	20850	"	"
"	408	408	"	"	"	"	"	"	"	"	"	"	"		"	"		"	"	"	21550	"	"
"	409	409	"	"	"	"	"	"	"	"	"	"	"		"	"		"	"	"	21700	"	"
"	410	410	"	"	"	"	"	"	"	"	"	"	"		"	"		"	"	"	21660	"	"
"	411	411	"	"	"	"	"	"	"	"	"	"	"		"	"		"	"	"	21650	"	"
"	412	412	"	"	"	"	"	"	"	"	"	"	"		"	"		"	"	"	21250	"	"

PLATE No. XX.

CHARACTERISTICS OF CARS.—C. C. C. CO'S RY.—CONT'D.

November 1909

Initial	Present Number	Old Number	Type: Gage	Type: Material	Type: Class	Maker	Truck: Kind	Truck: Journal	Truck: Dia. Whls.	Truck: Whl. Base	Truck: c c Trucks	Length: Over End Sill	Length: Over All	Length: Inside	Width: Over Side Sill	Width: Over All	Width: Inside	Height: Rail to Coupler	Height: Rail to Floor	Height: Rail to Top	Weight	Capacity: Cu. Ft.	Capacity: Lbs.
C	413	413	36"	Steel	Ingoldsby Auto Dump	Mount Vernon Car Co.	Rigid	4¼x8	24"	4'-4"	17'-3"	24'-1"	25'-10"		7'-1"	7'-11"		27"		7'-11"	21650	453	50000
"	414	414	"	Steel	Ingoldsby Auto Dump	Barney and Smith Car Co.	"	4¼x8	24"	4'-4"	17'-3"	24'-1"	25'-10"		7'-1"	7'-11"		27"		7'-11"	22100	453	50000
"	415	415	"	"	"	"	"	"	"	"	"	"	"		"	"		"	"	"	22450	"	"
"	416	416	"	"	"	"	"	"	"	"	"	"	"		"	"		"	"	"	22000	"	"
"	417	417	"	"	"	"	"	"	"	"	"	"	"		"	"		"	"	"	22250	"	"
"	418	418	"	"	"	"	"	"	"	"	"	"	"		"	"		"	"	"	22200	"	"
"	419	419	"	"	"	"	"	"	"	"	"	"	"		"	"		"	"	"	22400	"	"
"	420	420	"	"	"	"	"	"	"	"	"	"	"		"	"		"	"	"	22350	"	"
"	421	421	"	"	"	"	"	"	"	"	"	"	"		"	"		"	"	"	22150	"	"
"	422	422	"	"	"	"	"	"	"	"	"	"	"		"	"		"	"	"	22650	"	"
"	423	423	"	"	"	"	"	"	"	"	"	"	"		"	"		"	"	"	22350	"	"
"	424	424	"	"	"	"	"	"	"	"	"	"	"		"	"		"	"	"	21900	"	"
"	425	425	"	"	"	"	"	"	"	"	"	"	"		"	"		"	"	"	22150	"	"
"	426		"	Steel	Ingoldsby Auto Dump	American Car and Fdy. Co.	"	4¼x8	24"	4'-6"	19'-4"	26'-6"	27'-6"		7'-0"	7'-9½"		26¾"		7'-4½"	22300	448	60000
"	427		"	"	"	"	"	"	"	"	"	"	"		"	"		"	"	"	22100	"	"
"	428		"	"	"	"	"	"	"	"	"	"	"		"	"		"	"	"	22050	"	"
"	429		"	"	"	"	"	"	"	"	"	"	"		"	"		"	"	"	22350	"	"
"	430		"	"	"	"	"	"	"	"	"	"	"		"	"		"	"	"	22200	"	"
"	431		"	"	"	"	"	"	"	"	"	"	"		"	"		"	"	"	22200	"	"
"	432		"	"	"	"	"	"	"	"	"	"	"		"	"		"	"	"	22350	"	"
"	433		"	"	"	"	"	"	"	"	"	"	"		"	"		"	"	"	22100	"	"
"	434		"	"	"	"	"	"	"	"	"	"	"		"	"		"	"	"	22150	"	"
"	435		"	"	"	"	"	"	"	"	"	"	"		"	"		"	"	"	22200	"	"
"	436		"	"	"	"	"	"	"	"	"	"	"		"	"		"	"	"	22350	"	"
"	437		"	"	"	"	"	"	"	"	"	"	"		"	"		"	"	"	22200	"	"
"	438		"	"	"	"	"	"	"	"	"	"	"		"	"		"	"	"	22100	"	"
"	439		"	"	"	"	"	"	"	"	"	"	"		"	"		"	"	"	22250	"	"
"	440		"	"	"	"	"	"	"	"	"	"	"		"	"		"	"	"	22100	"	"
"	441		"	"	"	"	"	"	"	"	"	"	"		"	"		"	"	"	22450	"	"
"	442		"	"	"	"	"	"	"	"	"	"	"		"	"		"	"	"	22400	"	"
"	443		"	"	"	"	"	"	"	"	"	"	"		"	"		"	"	"	22090	"	"
"	444		"	"	"	"	"	"	"	"	"	"	"		"	"		"	"	"	22000	"	"

PLATE No. XXI.

CHARACTERISTICS OF CARS ~ C.C.C. CO'S RY. ~ CONT'D.

November 1909

Initial	Present Number	Old Number	Type: Gage	Type: Material	Type: Class	Maker	Truck: Kind	Truck: Journal	Truck: Dia. Whls.	Truck: Whl. Base	Truck: c-c Trucks	Length: Over End Sill	Length: Over All	Length: Inside	Width: Over Side Sill	Width: Over All	Width: Inside	Height: Rail to Coupler	Height: Rail to Floor	Height: Rail to Top	Weight	Capacity: Cu. Ft.	Capacity: Lbs.
C	445		36"	Steel	Single class by Auto Dump	America Car & Fdy Co.	Rigid	4¼x8"	24"	4'-8"	19'-4"	26'-8"	27'-6"		7'-6"	7'-8¼"		26½"		7'-4½"	22350	448	60,000
"	446		"	"	"	"	"	"	"	"	"	"	"		"	"		"		"	22300	"	"
"	447		"	"	"	"	"	"	"	"	"	"	"		"	"		"		"	22300	"	"
"	448		"	"	"	"	"	"	"	"	"	"	"		"	"		"		"	22300	"	"
"	449		"	"	"	"	"	"	"	"	"	"	"		"	"		"		"	22200	"	"
"	500	1		Steel	Single Hopper Bottom	Middletown Car Works	"	3¾x7"	24"	4'-4"	11'-5"	17'-11"	20'-3"		6'-7"	6'-7"		27"		7'-5"	16550	339	30000
"	501	3	"	"	"	"	"	"	"	"	"	"	"		"	"		"		"	16400	"	"
"	502	5	"	"	"	"	"	"	"	"	"	"	"		"	"		"		"	16400	"	"
"	503	7	"	"	"	"	"	"	"	"	"	"	"		"	"		"		"	16400	"	"
"	504	9	"	"	"	"	"	"	"	"	"	"	"		"	"		"		"	15750	"	"
"	505	11	"	"	"	"	"	"	"	"	"	"	"		"	"		"		"	16050	"	"
"	506	13	"	"	"	"	"	"	"	"	"	"	"		"	"		"		"	16400	"	"
"	507	15	"	"	"	"	"	"	"	"	"	"	"		"	"		"		"	16650	"	"
"	508	17	"	"	"	"	"	"	"	"	"	"	"		"	"		"		"	16150	"	"
"	509	19	"	"	"	"	"	"	"	"	"	"	"		"	"		"		"	16300	"	"
"	510	21	"	Steel	Double Hopper Bottom	Middletown Car Works	"	4¼x8"	24"	4'-4"	11'-7"	17'-10"	20'-5"		6'-1½"	6'-10"		27"		7'-9"	17050	402	60,000
"	511	23	"	"	"	"	"	"	"	"	"	"	"		"	"		"		"	17250	"	"
"	512	25	"	"	"	"	"	"	"	"	"	"	"		"	"		"		"	16000	"	"
"	513	27	"	"	"	"	"	"	"	"	"	"	"		"	"		"		"	17500	"	"
"	514	29	"	"	"	"	"	"	"	"	"	"	"		"	"		"		"	17000	"	"
"	515	31	"	"	"	"	"	"	"	"	"	"	"		"	"		"		"	17400	"	"
"	650		"	Wood	Gondola with Coke Rack	C.C.C. Co's Railway Shops	"	4¼x8"	24"	4'-4"	24'-2"	36'-1½"	37'-8¾"	34'-0"	8'-0"	8'-7"	7'-7"	2'-3½"	3'-8"	10'-0"	23200	1638	60,000
"	651	108	"	Steel	Gondola	"	"	3¾x7"	26"	4'-0"	17'-4"	28'-5"	30'-5"	25'-4"	6'-11"	7'-8"	6'-8"	27"	3'-3"	6'-3"	17200	509	60,000
"	652	109	"	"	"	"	"	"	24"	4'-3"	17'-3"	28'-7"	30'-6¼"	25'-9"	7'-3"	8'-4"	7'-0"	27"	3'-8"	6'-8"	20500	521	60,000
"	700	305	"	Wood	Box Car	America Car & Fdy Co.	"	4"x7"	26"	3'-7"	22'-3"	30'-2½"	32'-4"	29'-5½"	7'-2"	8'-3"	7'-0½"	26"	2'-8"	10'-4"	25070	611	50,000
"	701	307	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	2'-8½"	"	22900	628	"
"	750		"	Steel Frame	Box Car	C.C.C. Co's Railway Shops	"	4¼x8	24"	4'-4"	20'-4"	29'-1"	30'-9"	28'-6¼"	7'-11"	8'-7"	7'-5"	26"	3'-4"	11'-2"	23400	929	60,000
"	751		"	"	"	"	"	"	"	"	20'-5"	29'-6"	31'-1"	28'-5¾"	7'-11"	8'-10"	7'-4"	26"	3'-6"	11'-1"	23700	871	"

PLATE No. XXII

CHARACTERISTICS OF CARS. – C. C. C. CO'S RY. – CON'TD.

November 1909

Present Number	Air Brake.	Cost At Works.	Cost At Cananea	Entered Service.	Remarks.
25.	Westinghouse Auto 6" cylinder Aux Reservoir Combined Inside Connection.		$ 550.00	May - 1902.	Converted Box Car Nº and N. M. Ry.
N35.	Westinghouse Auto 6" cylinder Aux Reservoir Combined Inside Connection		$ 550.00		Truck of Destroyed Flat Nº 214 - Old Number
75.	Westinghouse Auto 6" cylinder Aux Reservoir Combined Inside Connection		$ 700.00	Sept. - 1903.	Converted Side Dump Nº and N. M. Ry.
76.	Westinghouse Auto 6" cylinder Aux Reservoir Combined Inside Connection.		$ 700.00		
100.	Westinghouse Auto 6" cylinder Aux Reservoir Combined Inside Connection.	$ 420.00	$ 474.97		
101.	" " " "	"	"		Destroyed in collision. Mar 21-1906.
102.	" " " "	"	"		
103.	" " " "	"	"		
104.	" " " "	"	"		Destroyed in collision. Sep. 21-1904.
105.	" " " "	"	"		
106.	Westinghouse Auto 6" cylinder Aux Reservoir Combined. Inside Connection.	$ 445.00	$ 515.41	Sept. - 1904.	
107.	" " " "	"	"	"	
108.	" " " "	"	"	"	
109.	" " " "	"	"	"	
110.	" " " "	"	"	"	
111.	" " " "	"	"	"	
150.	Westinghouse Auto 6" cylinder Aux Reservoir Combined. Inside Connection.		$ 304.17		Scrapped Feb 21-1908.
151.	Westinghouse Auto 6" cylinder Aux Reservoir Combined. Inside Connection.		"		4 Side Dump Cars - 2 Box Cars and 1 Caboose Cost $1575.00 at Morenci.
152.	Westinghouse Auto 6" cylinder Aux Reservoir Combined. Inside Connection.		"		Scrapped Oct 19-1909.
153.	Westinghouse Auto 6" cylinder Aux Reservoir Combined. Outside Connection		"		Converted Box Car. - Scrapped Feb-2-1908.
154.	Westinghouse Auto 6" cylinder Aux. Reservoir Combined. Inside Connection		"		
155.	Westinghouse Auto 6" cylinder Aux Reservoir Combined Inside Connection.		"		
200.	Westinghouse Auto 8" cylinder Aux Reservoir Combined Inside Connection.		$ 737.58	June - 1905.	
201.	" " " "		"	"	
202.	" " " "		"	"	
203.	" " " "		"	"	
204.	" " " "		"	"	
205.	" " " "		"	"	
206.	" " " "	$ 725.00	$ 978.35	Oct. 7-1907.	
207.	" " " "	"	"	"	
208.	" " " "	"	"	"	

PLATE NO. XXIII.

CHARACTERISTICS OF CARS.—C.C.C. CO'S RY.—CON'TD.

November 1909

Present Number	Air Brake	Cost: At Works	Cost: At Conneaut	Entered Service	Remarks
209	Westinghouse Auto 8 Cylinder Aux. Reservoir Combined Inside Connection	$726.80	$978.35	Oct. 5-1907	
210	″ ″ ″ ″ ″	″	″	″	
211	″ ″ ″ ″ ″	″	″	″	
212	″ ″ ″ ″ ″	″	″	Oct. 4-1907	
213	″ ″ ″ ″ ″	″	″	″	
214	″ ″ ″ ″ ″	″	″	″	
215	″ ″ ″ ″ ″	″	″	Sep. 19-1907	
216	″ ″ ″ ″ ″	″	″	″	
217	″ ″ ″ ″ ″	″	″	″	
218	″ ″ ″ ″ ″	″	″	Sept. 28-1907	
219	″ ″ ″ ″ ″	″	″	″	
220	″ ″ ″ ″ ″	″	″	Oct. 4-1907	
250	Westinghouse Auto 8 Cylinder Aux. Reservoir Detached Inside Connection		$750.00		Made from Frame of Traction Wagon.
300	Westinghouse Auto 6 Cylinder Aux. Reservoir Detached Outside Connection		$1100.00	Oct.-1902.	Bought from M.S. Ry.-New.
301	Westinghouse Auto 8 Cylinder Aux. Reservoir Detached Outside Connection		″	″	″
302	″ ″ ″ ″ ″		″	″	″
303	″ ″ ″ ″ ″		″	″	″
304	Westinghouse Auto 6 Cylinder Aux. Reservoir Detached Outside Connection		″	″	″
305	″ ″ ″ ″ ″		″	″	″
400	Westinghouse Auto 8 Cylinder Aux. Reservoir Detached Inside Connection	$1087.60	$1245.59	June 3-1904.	
401	″ ″ ″ ″ ″	″	″	″	Destroyed in Collision Jul. 6-1906.
402	Westinghouse Auto 8 Cylinder Aux. Reservoir Detached Inside Connection	$860.00	$1066.16	Apr. 30-1905.	
403	″ ″ ″ ″ ″	″	″	″	
404	″ ″ ″ ″ ″	″	″	″	
405	″ ″ ″ ″ ″	″	″	″	
406	″ ″ ″ ″ ″	″	″	″	
407	″ ″ ″ ″ ″	″	″	May 4-1905.	
408	″ ″ ″ ″ ″	$939.00	$1104.45	Aug. 29-1905.	
409	″ ″ ″ ″ ″	″	″	Sept. 1-1905.	
410	″ ″ ″ ″ ″	″	″	Aug. 29-1905.	
411	″ ″ ″ ″ ″	″	″	Sept. 3-1905.	
412	″ ″ ″ ″ ″	″	″	Aug. 31-1905.	

PLATE No. XXIV

CHARACTERISTICS OF CARS — C.C.C. CO'S RY. — CONT'D.

Present Number	Air Brake.	Cost. At Works	Cost. Rebuilt	Entered Service.	Remarks. November 1912
445	Westinghouse Auto 6 Cylinder Aux Reservoir Detached Inside Connection	$1115.00	$1291.33	Apr 8 1908	
446	.	.		.	
447	.	.		.	
448	.			.	
449	.			.	
500	Westinghouse Auto 8 Cylinder Aux Reservoir Detached Inside Connection	$716.00	$558.00		Purchased Dec 1911. Detroit Shops.
501	.	.			
502	.				
503	.				
504	.	.			.
505	.	.			.
506	.	.			.
507	.				.
508	.				.
509	.	.			.
510	.	$1000.00	$1200.00		Middletown Shops.
511	.				.
512	.				.
513	.				.
514	.	.	.		.
515	.		.		
[illegible]	.		$173.77	May 25-1907	Made from wrecked B & O Car No. 54258
[illegible]	Westinghouse Auto 6 Cylinder Aux Reservoir Detached Inside Connection		$900.00	May 10-1907	Flat Car made from frame of Traction Wagon - Later into Gondola
692	.		$969.00	July 9-1907	
700	Westinghouse Auto 8 Cylinder Aux Reservoir Combined Outside Connection	$730.00	$960.00	Mar 15-1902	Dto R.G. Standard.
701	.			Mar 22-1902	
750	Westinghouse Auto 8 Cylinder Aux Reservoir Detached Inside Connection		$510.95	Apr 10-1907	
751	.		$666.49	Sep 20-1907	

Approved. T. R. Stalling
Superintendent of Railways

PLATE No. XXVI

2' X 2' 6" or a total area of 10 square feet, and the dumping space of the latter is composed of four openings 2' 2" X 2' 5" or a total area of 20.9 square feet.

The small dump openings permit the ore to form an arch in the car, so that a portion of the material next the openings will run out but the top of the arch generally has to be broken before the contents of the car will be discharged. If the ore is sharp and clean and of a size to pass a two inch ring or larger, as the Elisa, Eureka and Henrietta ore, the arching effect while present is easier broken down. With concentrates or ore containing talc this arching is so pronounced that at times it is ne~~x~~essary to literally dig the material out of the cars. Especially is this true of the fine concentrates, which are loaded by water, for by the time these cars reach the smelter the jolting thoroughly packs the fines in the bottom of the cars and forces the water to the top.

The time required to discharge material from these types of cars varied of course, but it not infrequently required half an hour per car and occasionally twice that length of time. The cost of unloading is represented not only by the time of the laborers actually performing the work but the time of the train

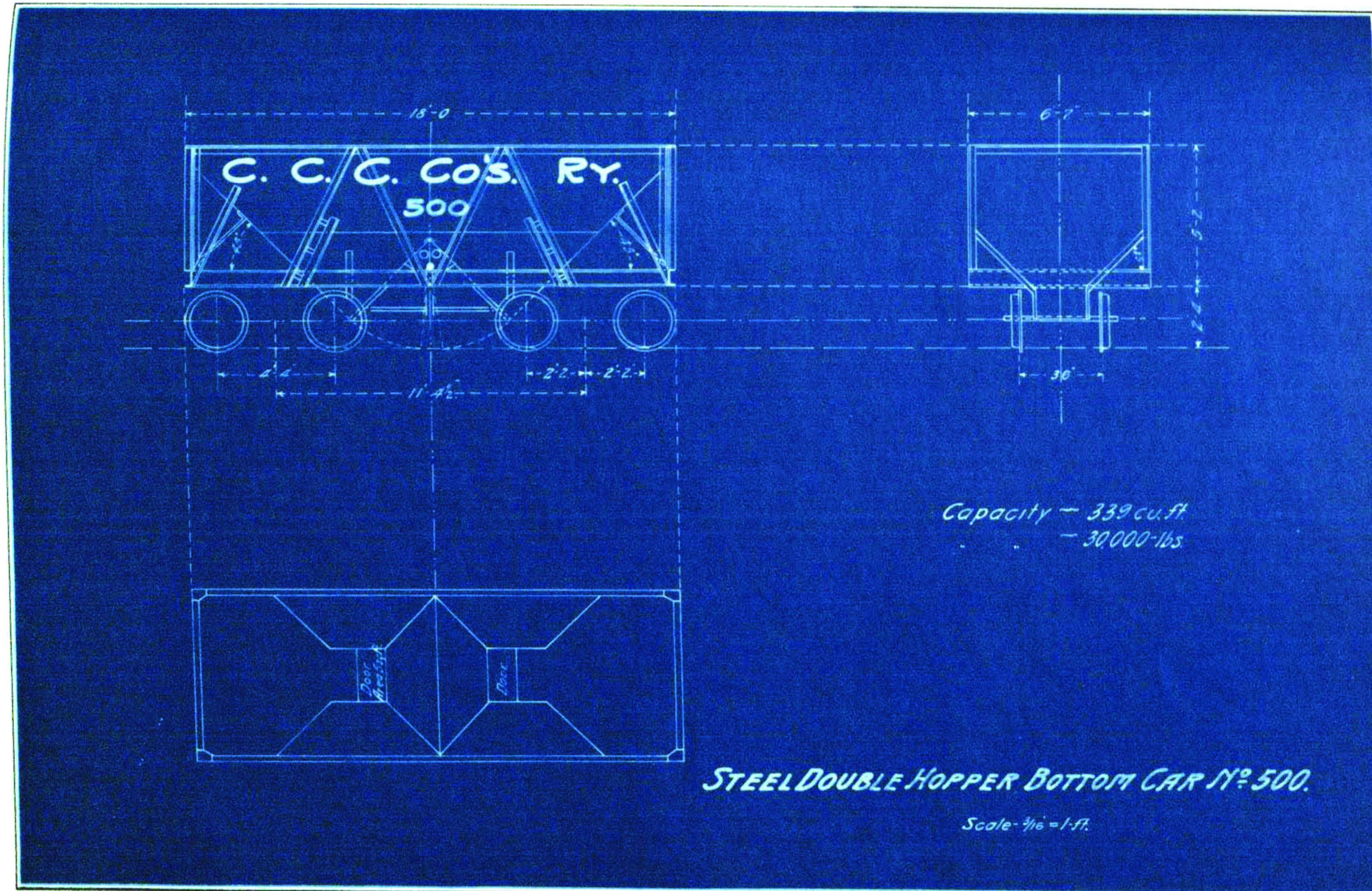
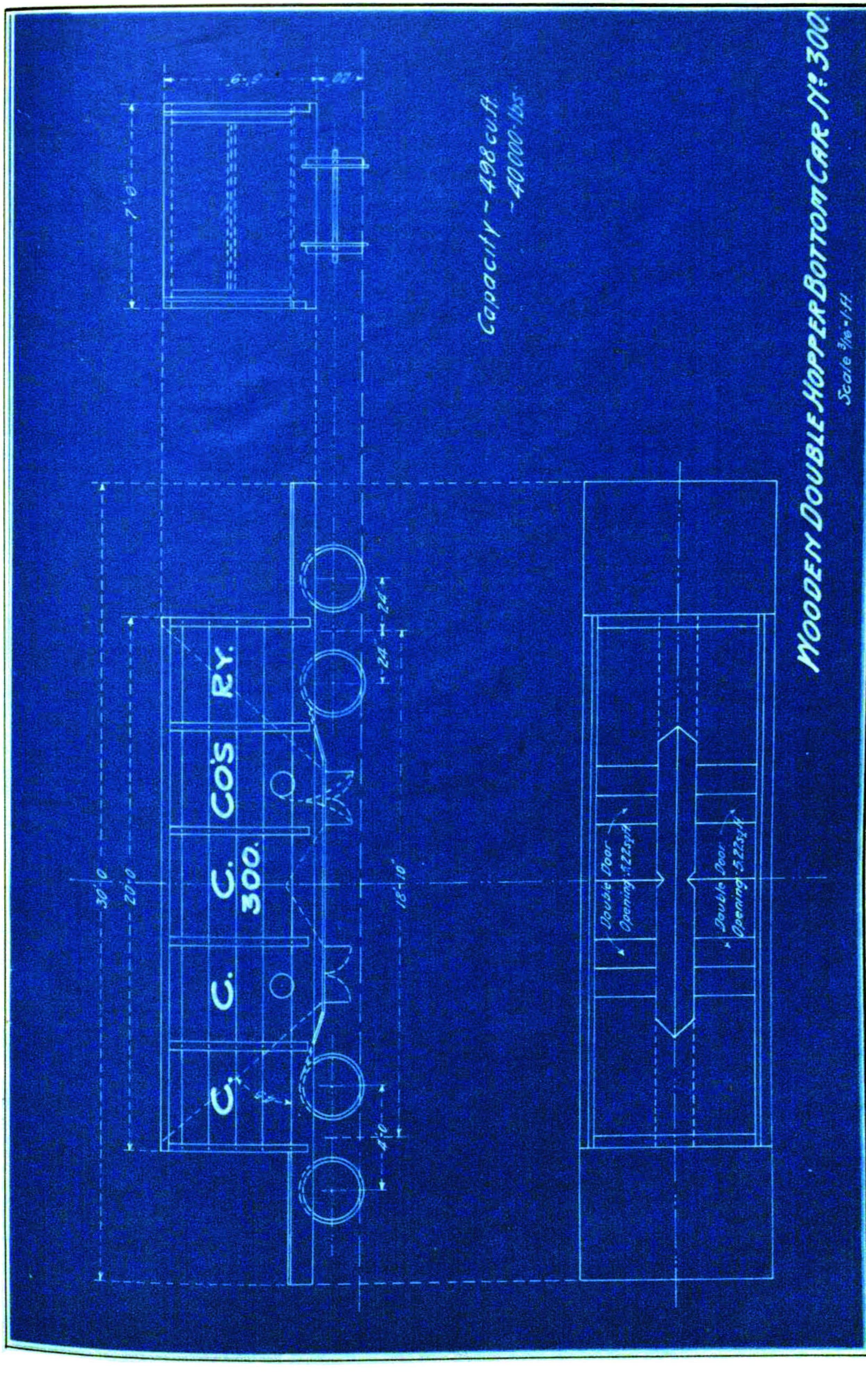


PLATE No. XXVII

PLATE No. XXVIII



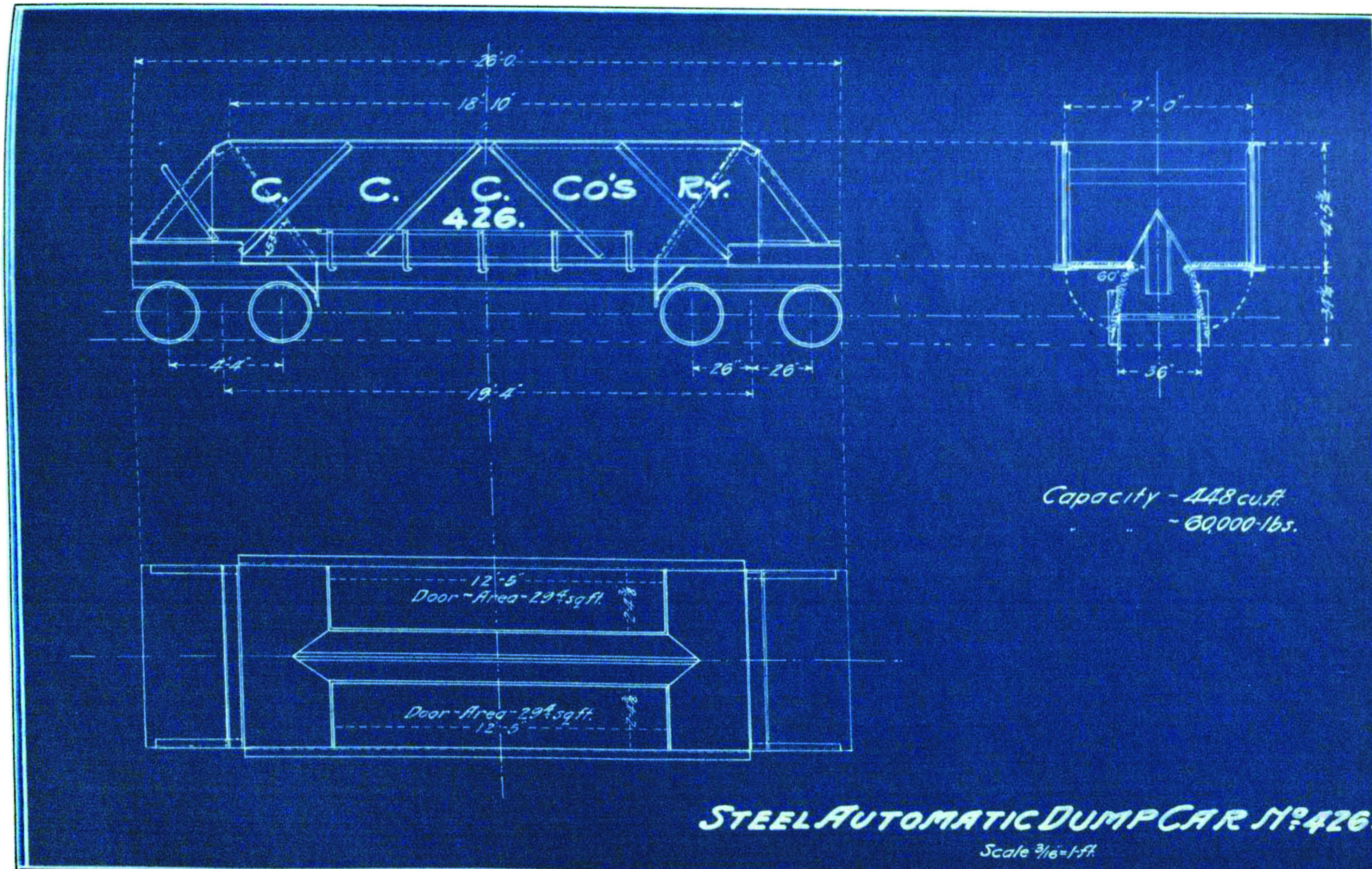


Plate No. XXIX.

crew as well, and thereby the loss of earning power of locomotive and cars, and it is evident that to reduce the time of unloading to a minimum is as important as getting the trains over the road in the minimum time. Thus it became evident that the ore cars that were in the service should be used in the hauling of a coarse hard ore and an improved type of dump car should be procured for the con entrates and talc ore.

About this time F.S.Ingoldsby of St Louis, Missouri, brough out his first Automatic Dump Car, and two wooden cars of this type were bought for experiment. The car had many defects, but it proved its worth by being able to quickly discharge the slimiest kind of Concentrates. After this experimental car Mr. Ingoldsby designed one on the same principles to be built entirely of steel and corrected the mechanical defects of his first car. Six of the steel cars were ordered for trial, and so extremely satisfactory did they prove that more were purchased with the growth of the plant and now there are forty eight in service.

The important features of the dumping arrangement of this car may be seen at a glance by referring to the drawing of this car on page 49. The sides of the car are vertical, the ends are built on a 53 degree slope, and an A with 60 degree slopes extends lengthwise through the car. The flat bottoms of the car are hinged to this A construction thus forming two doors 2' 5" X 12' 2" giving a total area of dumping service of 58.8 square feet, which is so large in comparison to the total bottom area that no arching is possible. With ordinary ore the discharge is instantaneous; with concentrates all the material is quickly discharged except that which clings to the sides of the car by virtue of its moist condition and compressed air is now used to complete the unloading.

In discussing the saving in time of unloading effected by the use of an improved type of car, reference was made to the earning power of a locomotive as the basis for computing the amount. The earning power of a locomotive is considerably greater than the cost of operating the same, but it does seem that it is not necessary to introduce a lengthy discussion of this topic here, especially when by simply using the cost of operating a locomotive as the basis of comparison, sufficient saving can be shown to prove that the investment soon did pay for itself.

The average saving in time of unloading a twelve car train of Ingoldsby cars - of all classes of material - over a similar train of the other types is one minute per car or twelve minutes per train. It has already been shown that Engine No.9 operating at a cost of $6.51 per engine hour can haul six trains or seventy two cars of ore from Capote to the Smelter. With a saving in time of unloading of one minute per car, the daily saving would be seventy two minutes or 1.2 hours, which at $6.51 per engine hour represents a saving of $7.81 per day or $2850.65 per year. The purchase of twelve such cars requires an expenditure of $14791.42; the annual saving of $2850.65 just mentioned, represents 19% interest on the investment.

Practically all new equipment of other classes of cars that was purchased after 1903 was specified to be built with steel underframe and of 50,000 to 60,000 pounds capacity. Thus the tonnage capacity of the cars being increased, the tonnage capacity of the locomotives was increased - hauling more tons of material per ton of car - and as the cost of maintenance of steel cars is less, the cost of transportation is cheapened.

At the close of the fiscal year December 31, 1910, the rolling stock consisted of the following equipment:

Freight Equipment

6	Wooden Hopper Bottom Ore Cars,	40000	Cap'y
10	Center Dump Steel Ore Cars,	30000	"
6	" " " " "	60000	"
1	Wooden Ingoldsby Automatic Dump Car,	50000	"
24	Steel " " " "	50000	"
24	" " " " "	60000	"
4	Wooden Flat Cars,	30000	"
2	" " "	35000	"
6	" " "	50000	"
22	Steel Flat Cars,	50000	"
1	Gondola Wooden Underframe,	60000	"
2	" Steel "	60000	"
2	Box Cars - Wooden Underframe,	50000	"
2	" " Steel "	60000	"
1	Wrecking Car,		
1	Caboose,		

Passenger Equipment

2	Observation Cars,		
116	Cars Total Equipment		

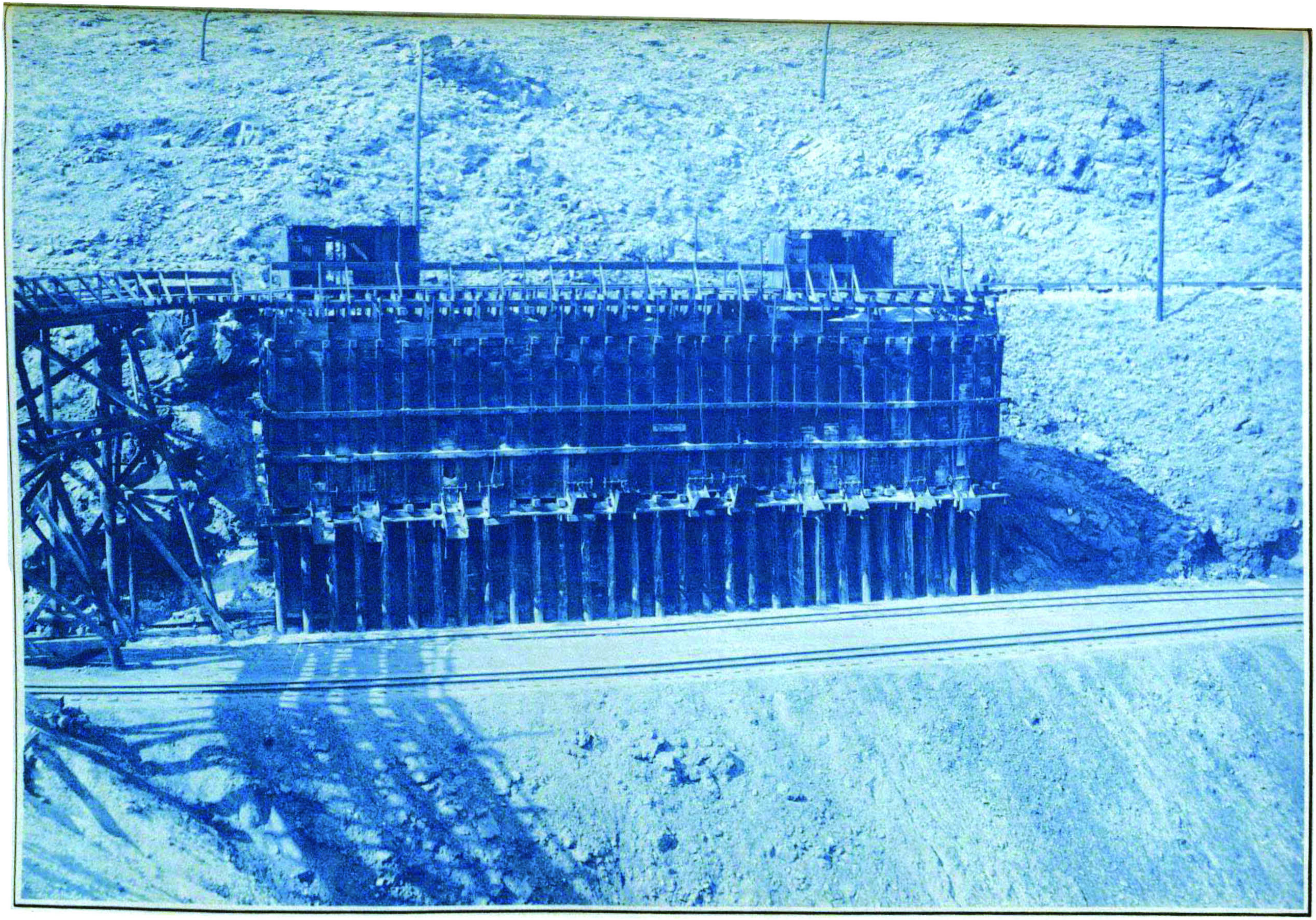
Increase of equipment in 1910 over equipment in 1903 - 262.5%.

Improved Type of Ore Bins
(See Plates 31 to 34 Inclusive)

This problem is similar to the one just discussed, except that this considers the economy of loading ore at the mines, the other that of unloading at the Smelter; in both cases the minimum time to do the work is the aim.

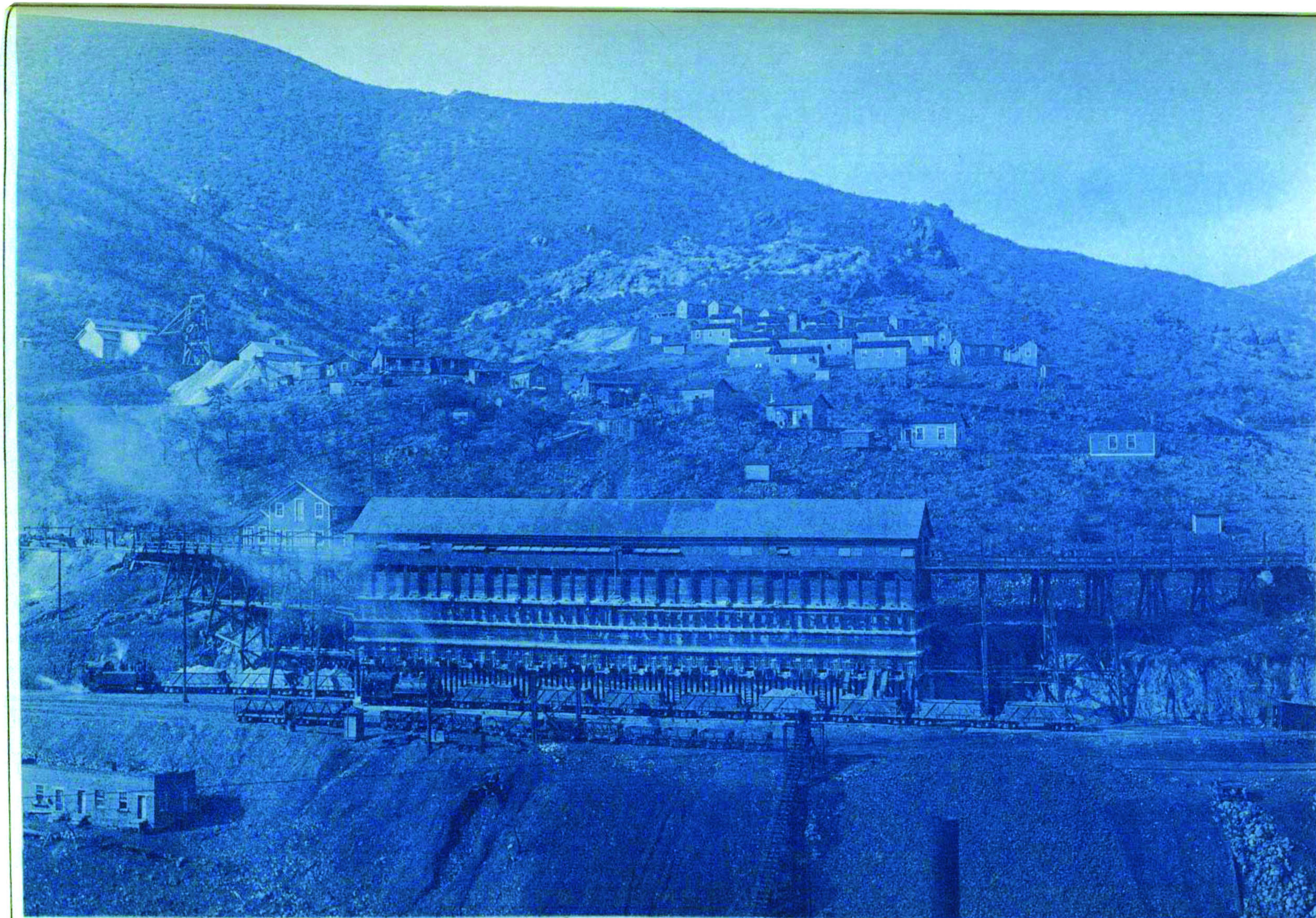
The first ore bins built in Cananea were flat bottom and with two small door openings on the fron of each twelve foot pocket (See Plate No.30 - Page 55). It is evident that not more than half of the ore would run out, depending upon the angle of repose of the material, so that in order to empty the bin, laborors would be put in the bin to shovel the remaining half of the ore from the bin to the car. This shoveling increased the loading cost and unless the shoveling was done, of what use would be that portion of the bin. Generally, however, this ore was left in the bin to form an incline for the balance of the ore to slide on. In this case the bin must be built as strong again as was necessary for the available capacity.

This led to the adoption of the bin with a 45 degree floor lined with 3/16" steel plates to prevent wear of the wooden bottom and to decrease the angle of repose. The bin was a decided improvement over those first constructed but the time required to load cars indicated that there was room for vast improvement in the gate ar-



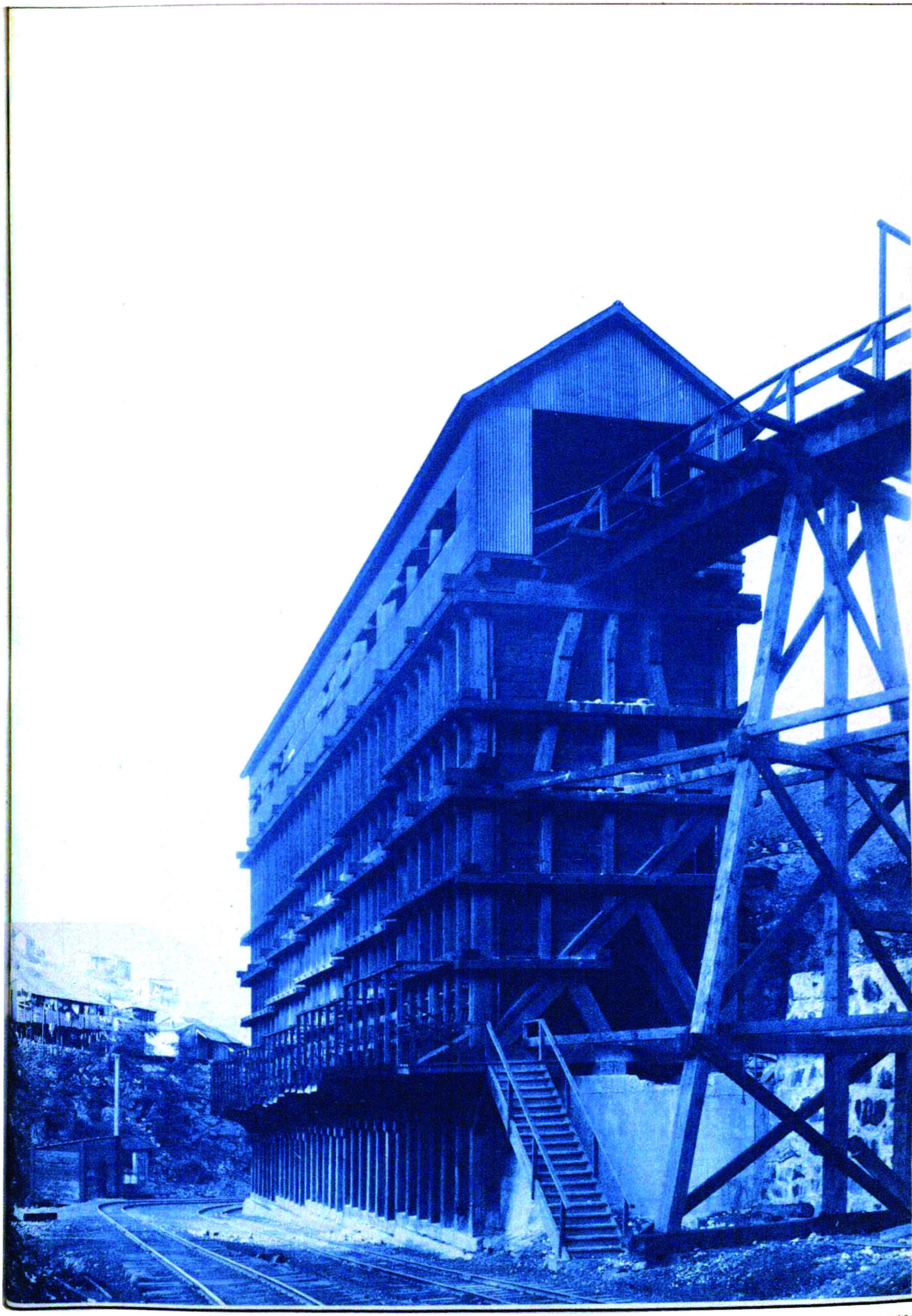
FIRST TYPE OF ORE BINS AT CANANEA - FLAT BOTTOM WITH 2 SMALL GATE OPENINGS PER POCKET.

PLATE No XXX



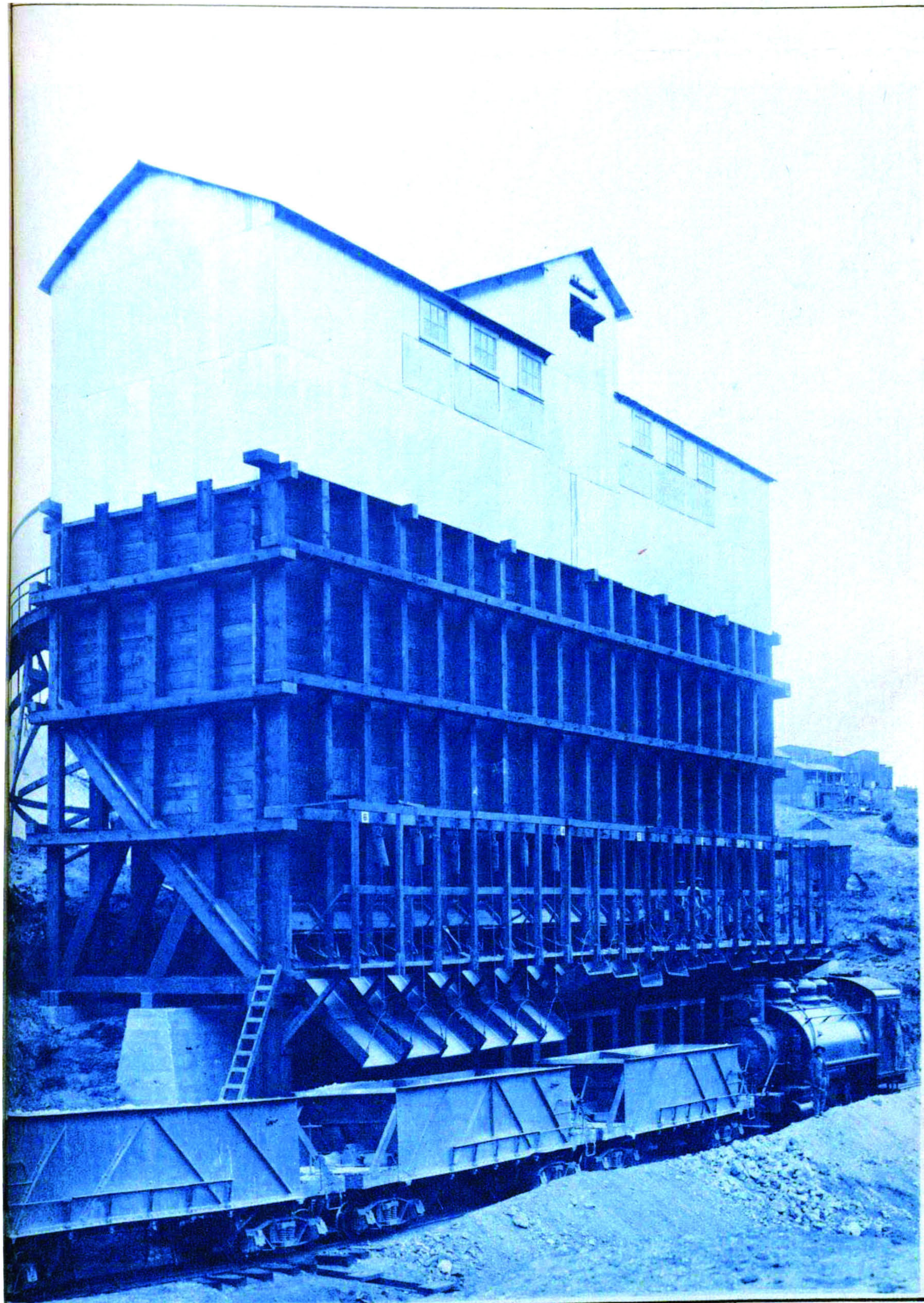
VETA NO. 9 ORE BINS - CAPACITY 6000 TONS - 45° BOTTOM WITH 2 GATES PER POCKET. LATER CHANGED TO 3 GATES PER POCKET

PLATE NO. XXXI

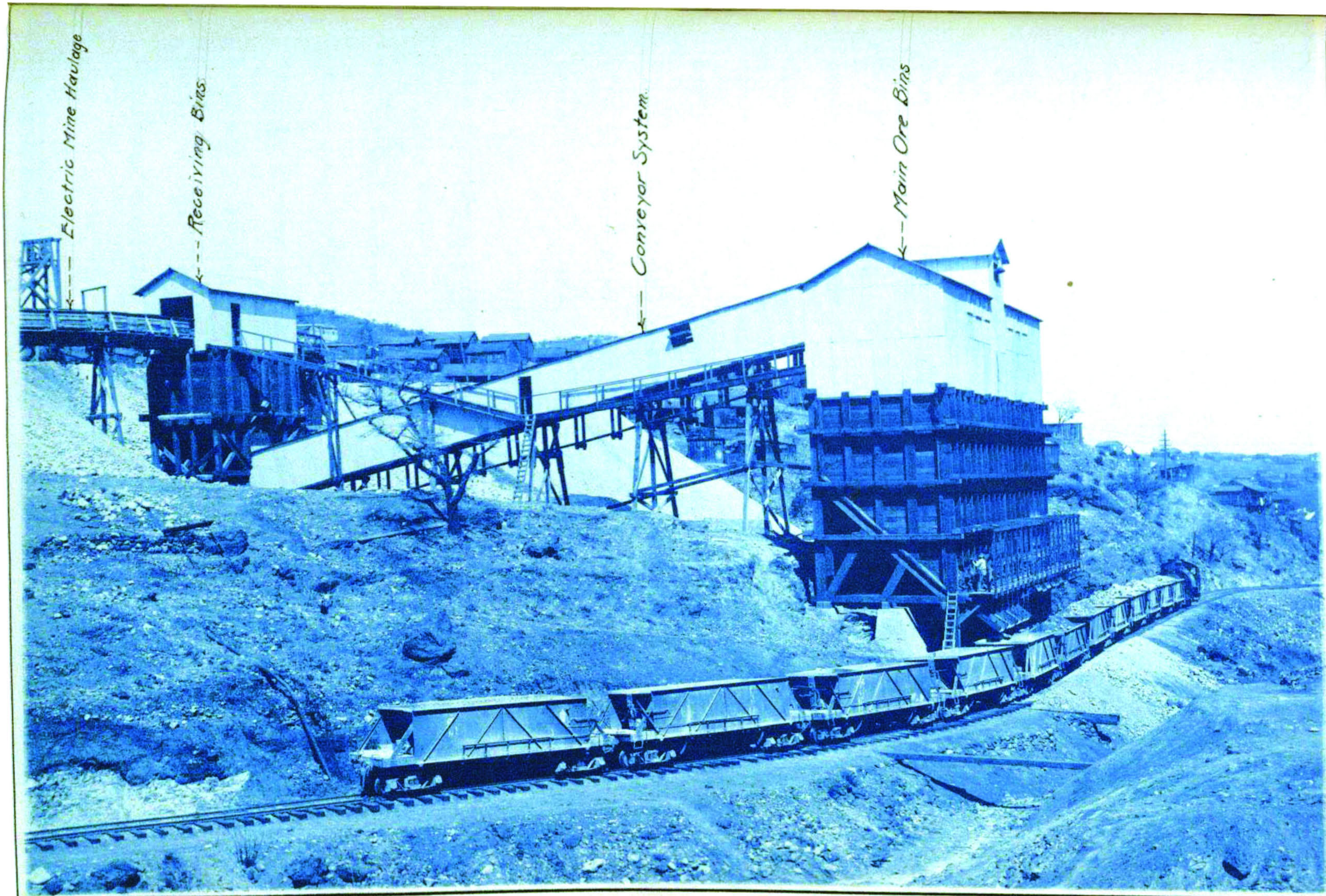


E ORE BINS - FIRST BINS BUILT WITH 45° STEEL LINED BOTTOM & 3 ARC GATES PER POCKET

PLATE NO XXXII



TE ELISA ORE BIN - STANDARD TYPE SHOWING 45° FLOOR & CONTINOUS OPENINGS.
PLATE No XXXIII

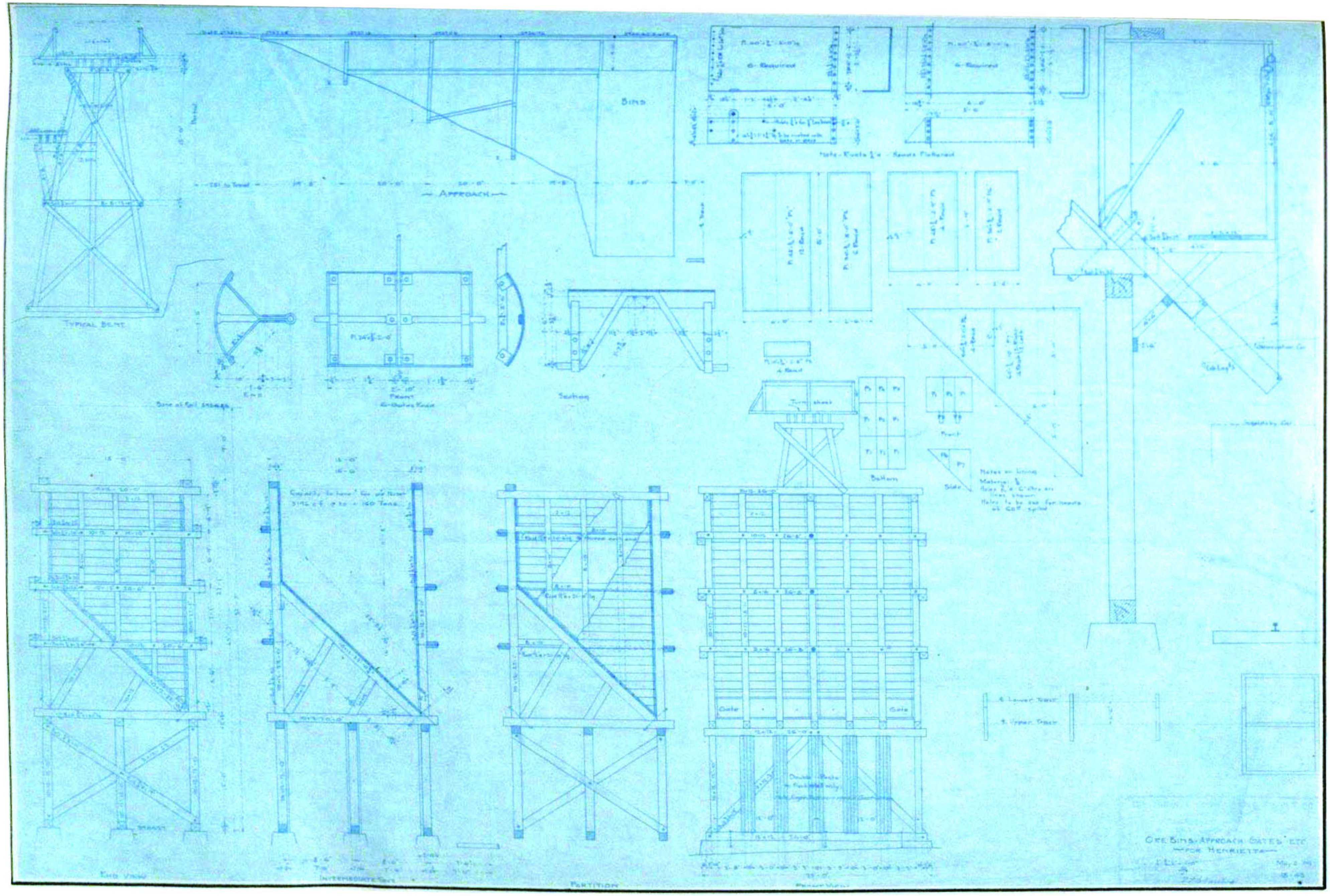


CAPOTE - ELISA ORE BINS SHOWING GENERAL ARRANGEMENT. ENGINE No. 9 LOADING 12 CARS.

PLATE No. XXXIV

rangement. Twelve feet was adopted as the standard length of pocket, and four feet centers of front posts; thus there are three panels in each pocket. The size of the gate opening had been increased from 14" x 19" to 2' 1" X 2' 1", with a rack and pinion gate placed in the first and third panels. The arching of the ores mentioned in a former discussion is very pronounced in ore bins, and in this case the arch was supported by the side of the pocket and the middle panel. In high ore bins it is difficult to break such an arch from the top and equally difficult from the bottom, so that a change in design became necessary. The difficulty was overcome by changing the rack and pinion gate to an arc gate making the gate openings 1' 10" x 3' 0" and placing a gate in the middle panel (See Standard Plan, Plate 35 - Page 61). This left no obstruction to the flow of the ore except two posts eight inches thick on the face of the bin. Thousands of dollars have been saved the company by this simple change in design. When the three gates are opened the ore arch has no support except the sides of the pockets; the arch can not support itself with such a span, thus the arching effect is broken and the ore runs freely, so that except when large rocks clog the doors, which occasionally happens, trains are loaded requiring but one minute per car, including spotting of the train.

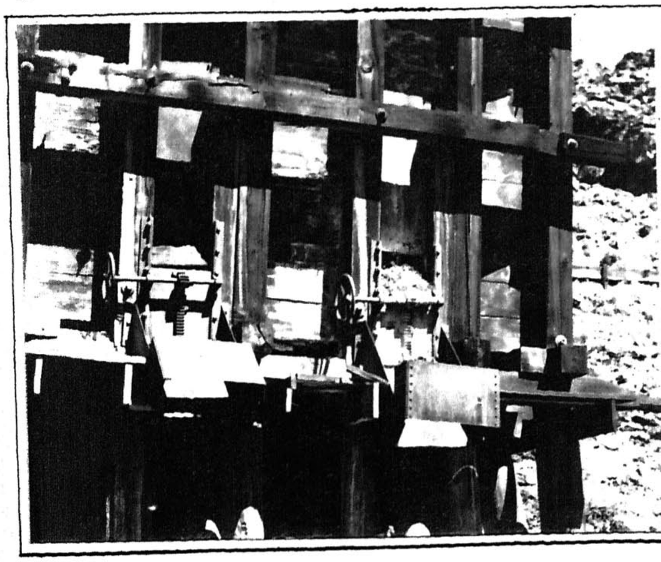
It is difficult to say just what saving has been



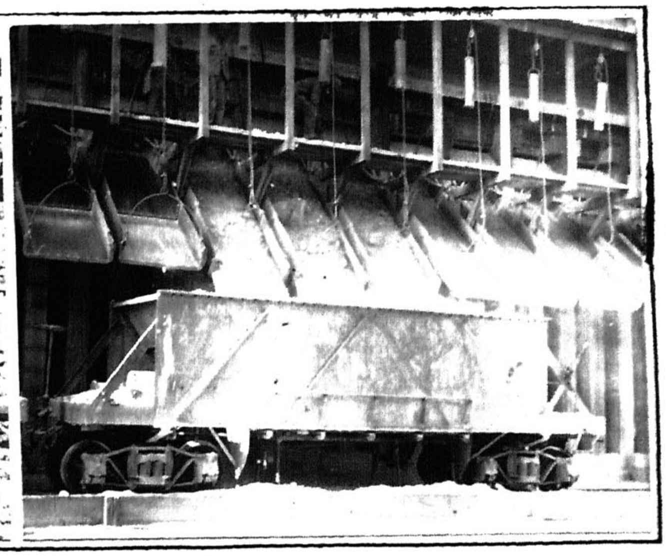
Standard Type Ore Bin

Plate No. XXXV.

made by the improvement in the type of bins, as that would require closer data of time required to load than was kept. From the data kept it is known that the change in type from the two rack and pinion gates to the three arc gates, easily showed a difference in time of loading of one minute per car or from the discussion of Improved Type of Rolling Stock, a saving of $2850.00 per year which represents 10 % interest on an expenditure of $28500.00. From the writers familiarity with the problem on account of his daily association for eight years with this and like problems he is reasonably certain that the saving effected by the use of the 45 degree iron bottomed bin with the three arc gates over the old style flat bottom bin with the two small rack pinion gates amounts to sufficient to pay 15% interest on the expenditures for mine ore bins since 1903, notwithstanding that this expenditure in round numbers amounts to $100,000.00.



OLD STYLE BIN
DOOR OPENING — 14"x15"



LOADING ORE FROM STANDARD TYPE ORE BIN
WITH CONTINOUS GATE OPENINGS.

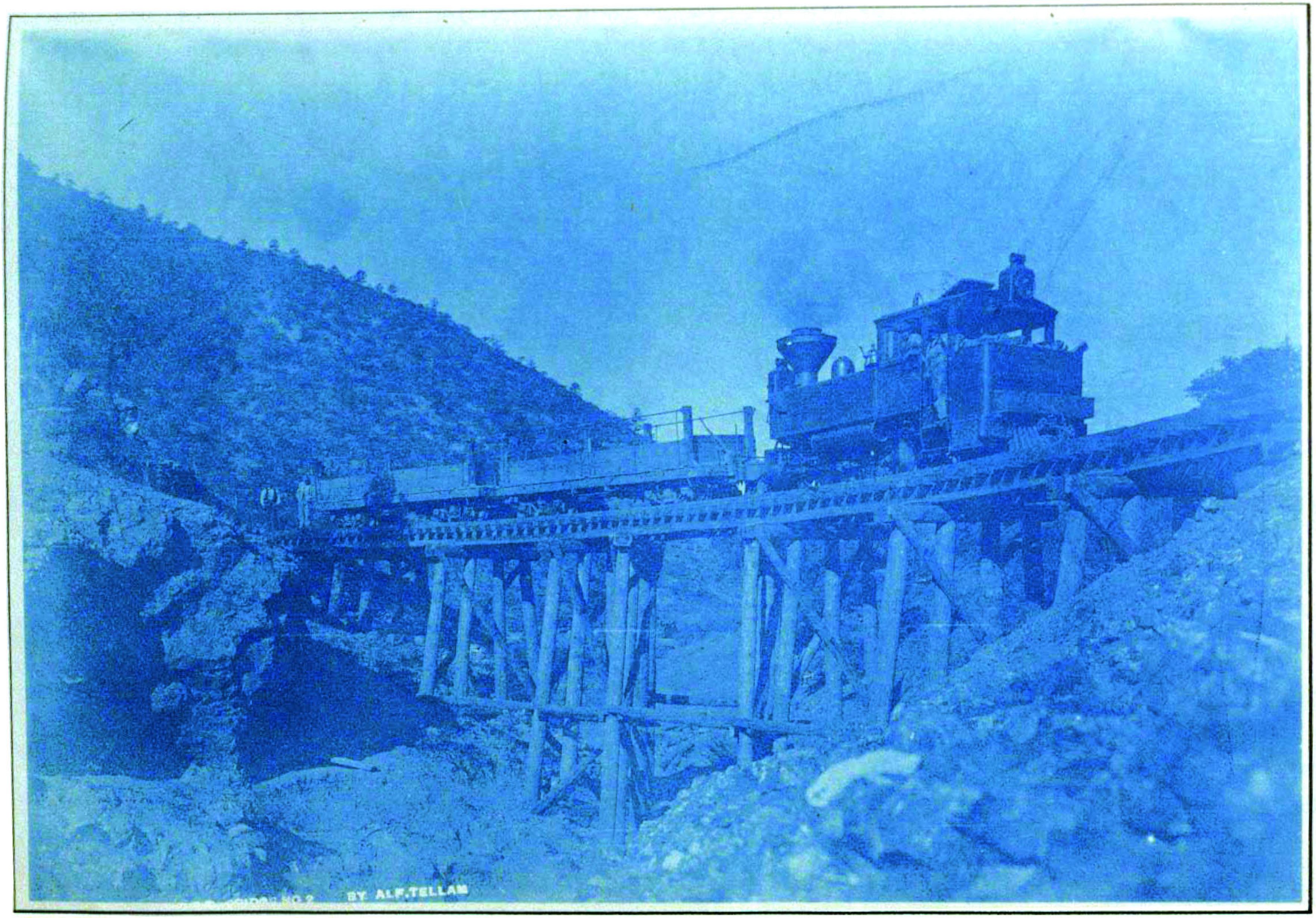
Miscellaneous

The most important changes made have been discussed, there were however a number of minor reforms introduced which will be treated under this heading.

Reduction of Maximum Degree of Curve

It has been stated that the road originally was located with maximum degree of curve of 54 degrees American system. It was soon shown in operation that even the lightest engines, Nos 1 and 2, with driving wheel base of but eight feet would not operate satisfactorily on that curvature. The line was changed in such places to maximum 45 degree curves, but no definite length of tangent between curves was adopted as standard, so that immediately below Capote, on the then busiest portion of the line, were located reverse 45 degree curves on a trestle (See Plate No.38 - Page 64). Trains ascending a grade with their maximum load, would generally stall on this piece of track, requiring that the engines double from this point, thus delaying its own movement and blocking other trains. A thorough study of the alignment of the road showed that it would be possible, with reasonable expense to adopt for standard, maximum 40 degree curves with not less than 60 feet of tangent between.

The necessary changes of line were made and the reduced cost of transportation abtained thereby, on



REVERSE 45° CURVES ON A TRESTLE NEAR CAPOTE. ORIGINAL LOCATION

PLATE No. XXXVIII

account of lesser delays in getting trains over the road, fewer derailments because of better alignment and reduced cost of maintaining the track has proved that the expenditures necessary to correct the line for the standard adopted were profitably spent.

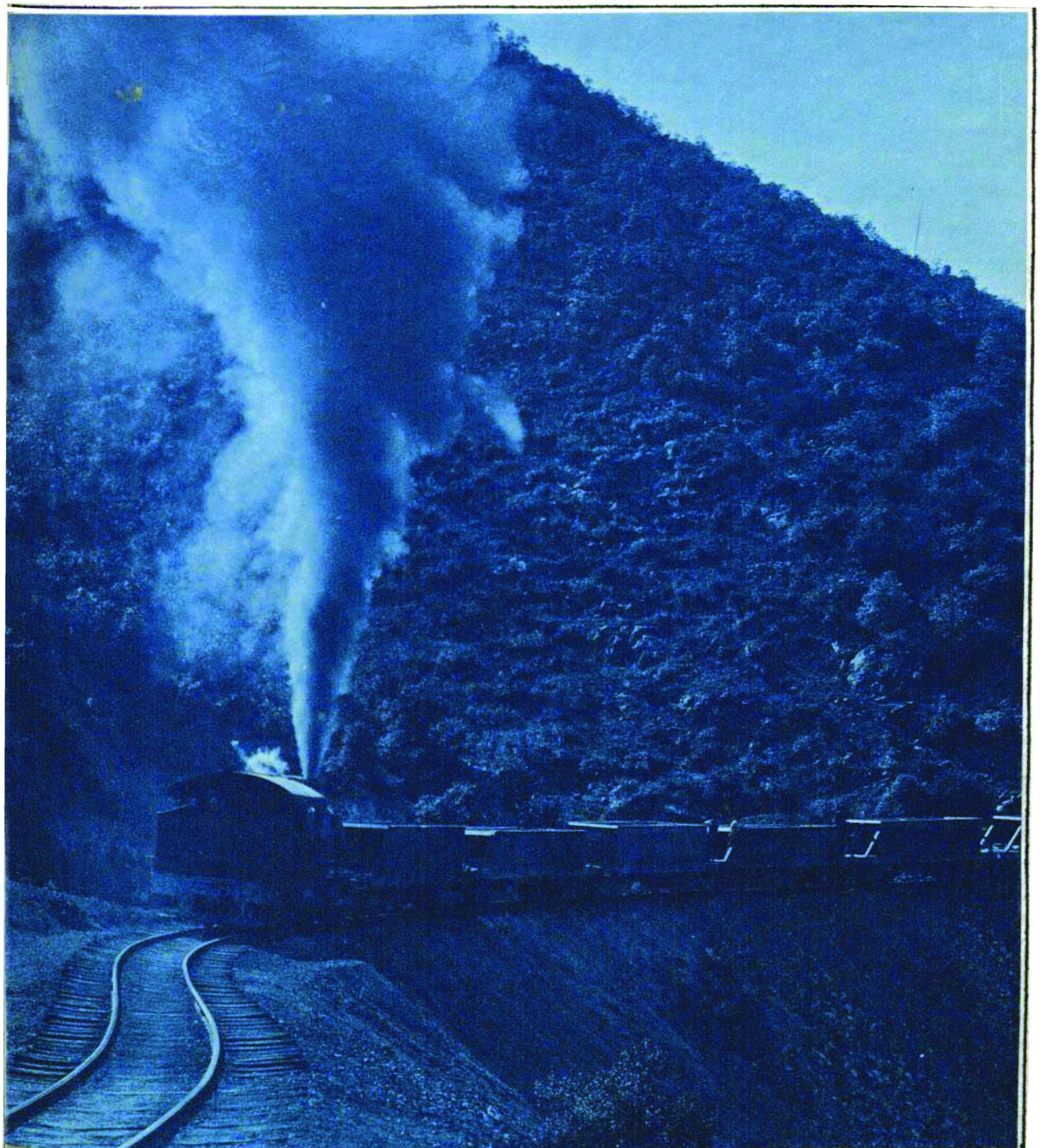


PLATE NO. XXXIX.

40° CURVES BETWEEN CAMPANA & PUERTECITO.

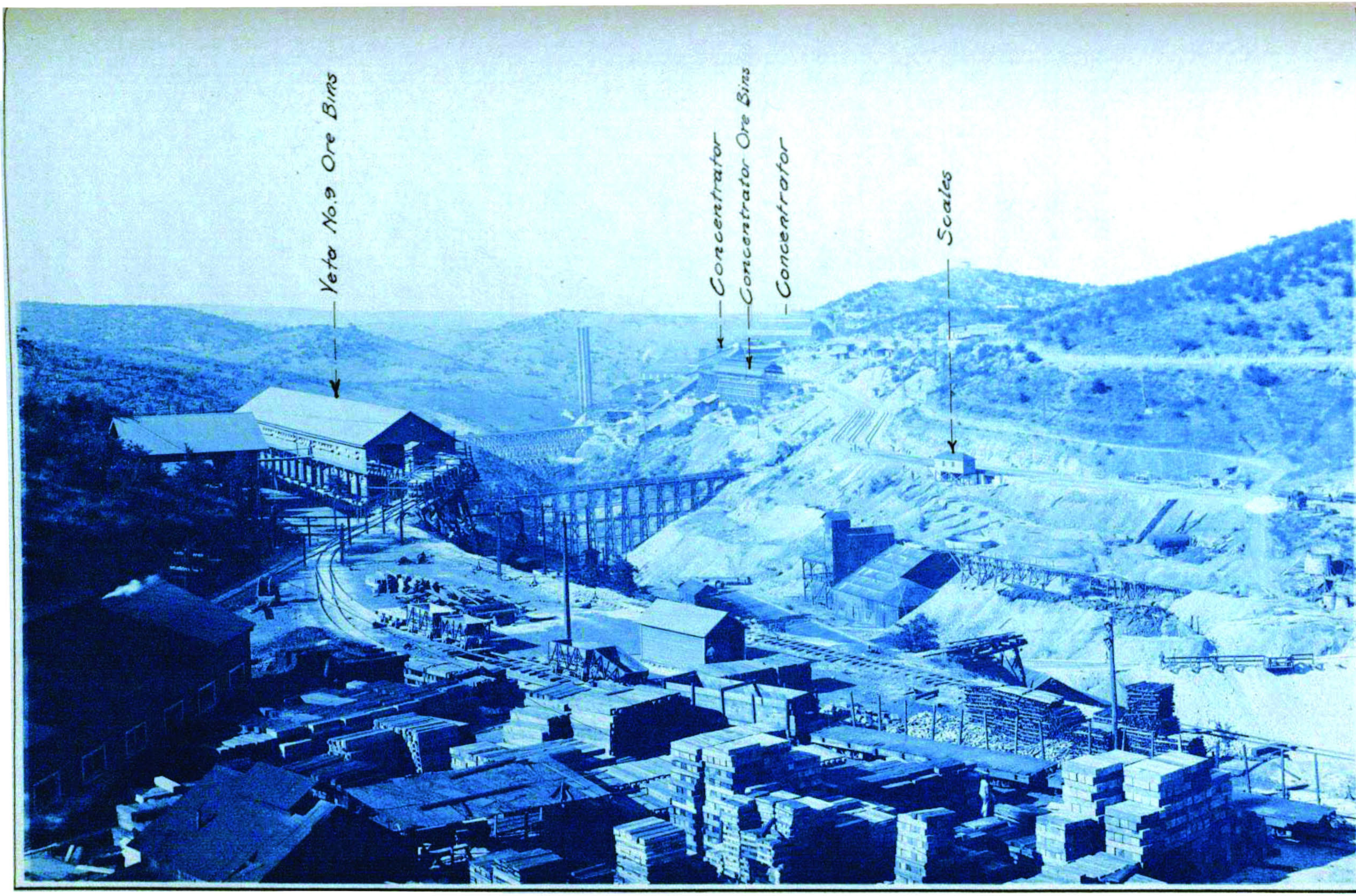
Double Track from Concentrator to Buena Vista

In 1902 Track Scales were installed near the Concentrator and the line was double tracked from the Smelter to the Concentrator. Shortly after this a new Concentrator and a six thousand ton ore bin near the portal of Veta #9 Tunnel was built (See Plate No.40 - Page 67).

At this time all of the ore was produced from the mines beyond the cencentrator, so that 2000 tons of ore and fluxes, 500 tons of concentrates and all the supplies from the mines had to be hauled daily over a single track by trains, which on account of the lack of heavy motive power, could haul but 180 tons per trip. The coarse ore bin for the new concentrator had been built between the concentrator and the mines, thus requiring that the second class ore be handled past the concentrator bins to the scales and then back to the bins, thus making a longer haul and confusing the traffic.

The remedy for these evils was simple; a plan extending the double track to Buena Vista and locating the scales on an independent track between the Veta No.9 Ore Bins and the Concentrator Coarse Ore Bins was drawn up, and as it required a very nominal expenditure, the construction was authorized.

The work cost $25055.00, and the benefits are so great, that it can nearly be classed with the important



GENERAL VIEW OF CONCENTRATOR FROM VETA NO. 9 LUMBER YARD

PLATE NO. XL.

reforms. The Dispatching is done by telephone; by the introduction of this double track, all the ore from Veta No.9 Ore Bins to the Concentrator and the Smelter can be handled without delay to a single train, and the work of dispatching was so reduced, that the position of Chief Clerk and Dispatcher was consolidated, alone making a saving of $1800.00 per year or 7% interest on the investment. The saving made in reduced dealys to trains is much greater than this, but owing to the work being largely of a yard nature, and not constant at that, the actual saving in percentage is difficult to determine.

Safe Guards for Handling Heavy Trains Descending Steep Grade

As mentioned in a former discussion, one of the most important items in the operation of this mountain raod, is to handle the trains safely in descending Campana and Capote Hill. The following items are important factors in this consideration:

Efficient Locomotive Engineers,

Thorough Air Inspection,

Safety Switch below Capote,

The first item requires no comment as it consists in employing none but competent men.

All the locomotives are equipped with 9-1/2" Westinghouse Air Pump, with main reservoir pressure of 110 pounds and train line pressure of 90 pounds. All the cars are equipped with Automatic Air Brakes with 8" Cylinders. The locomotives are equipped with steam brake applied to all the driving wheels. The engineer handles the train with the air on the cars, assisted by the steam brake of the engine. No hand brakes are applied unless the engineer whistles for them. Formerly the trainmen were provided with brake clubs, and when descending the hill, "clubbed up" the brakes; but this practice was discontinued on account of the number of slid wheels it developed, furthermore most engineers prefer to handle the trains themselves, calling upon the reserve hand brake power if needed.

For thorough inspection of air, a competent air man is employed to test the brakes daily. In addition to this, trains are stopped at Campana just before beginning the descent, and the conductor inspects his train before giving signal to the engineer to proceed.

It is evident that if a train descends with too great momentum, it may derail when it hits a 30 or 40 degree curve, but if the engineer has plenty of air, he can keep his train running with reasonably safe speed. If however in descending Campana Hill the engineer allows his train to proceed with slightly too great initial speed, he may find that his applications of air, while tending to check the train somewhat, do not however reduce his train to a safe speed, or the equipment not being in perfect repair, some of the air may be lost by leakage, and having delayed calling for hand brakes, thinking he still had ample time to check his train, he may suddenly find that his train has acquired such momentum as to be nearly beyond his control. He may reverse his engine and hold his train but in doing this he may lock the steam brakes and slide the drivers thus causing hundreds of dollars damage to the equipment, or as events happen quickly in such times, he may lose control of his train.

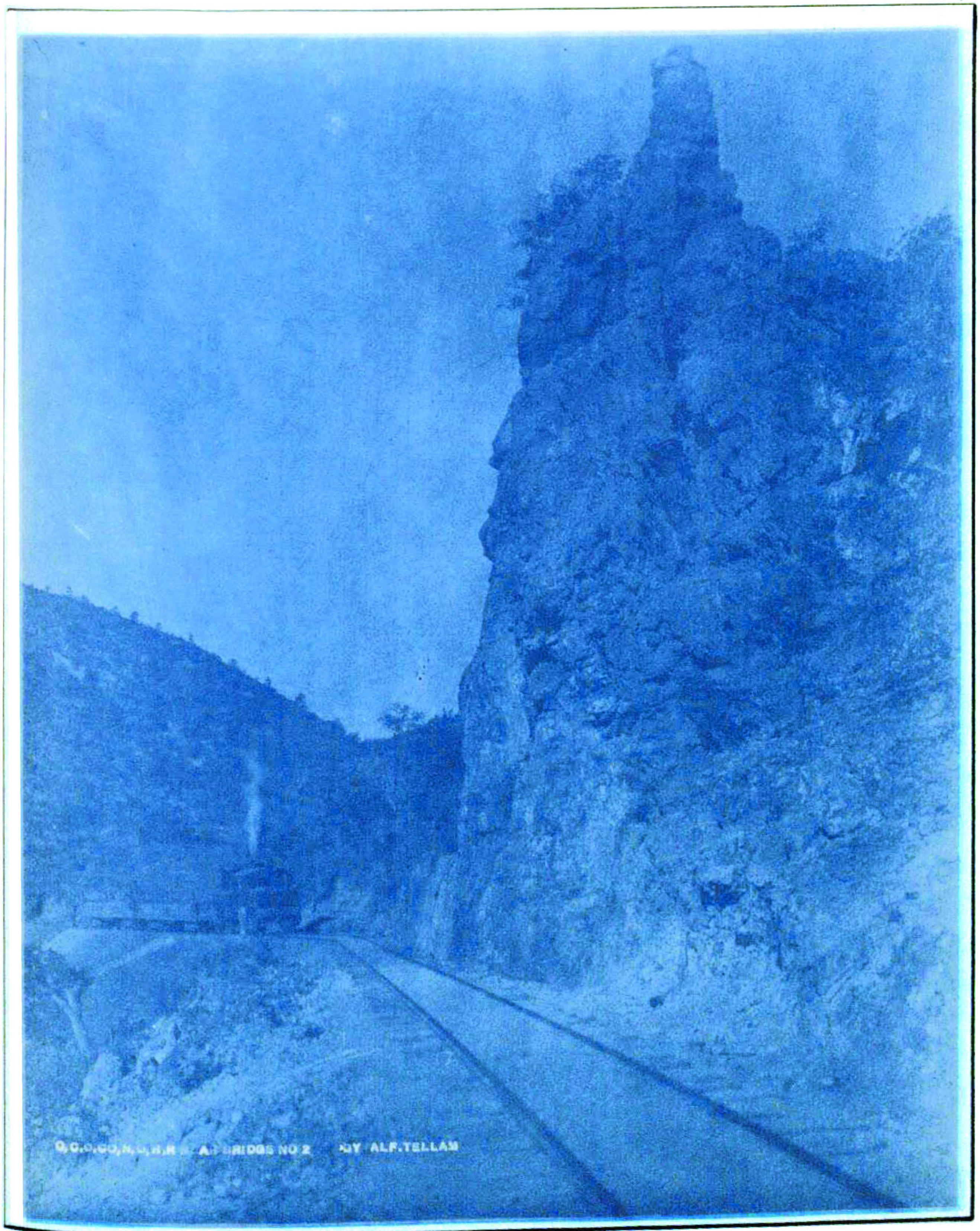


PLATE No. XLI.

TYPICAL SCENERY

To meet such possibilities a safety spur - See Plate 10, Page 21 - on an 8% grade was built below Capote about half way between Campana and the foot of the hill. A tender keeps the switch lined for the safety spur except when the engineer whistles that it is wanted for the main li ne. Engineers are required to bring their trains to a full stop above this switch and recharge the main air reservoir and test their air before completing the descent, thus the engineer is assured control of his train before leaving Capote. If the train is beyond control above Capote, it will run in on the Safety Spur and be brough to a stop without serious damage because of the steep grade of the spur.

When it is considered that the engineer is guardian of the lives of those on the train and from $15000.00 to $25000.00 of equipment, it should not seem that these precautions are superfluous.

Cheaper Labor

Prior to 1908, the train crews were made up of Americans; since that time, Mexicans have been broken in to act as conductors, brakemen and firemen. The saving per train crew is shown herewith:

Engineer (American)		$5.00 per day	
Fireman	"	3.50 "	
Conductor	"	4.25 "	
Brakeman	"	3.50 "	
			$16.25 p day
Engineer (American)		$5.00 "	
Fireman (Mexican)		2.25 "	
Conductor	"	2.50 "	
Brakeman	"	1.75 "	
			11.50 "
	A saving of---------		$ 4.50 "

or $1733.75 saving per train crew per annum.

Oil for Fuel

In 1908 the company obtained a concession from the Mexican Government for the importation of fuel oil free of duty. All the locomotives were changed from coal to oil burners, and an important saving is represented thereby, as will be shown herewith.

Engine No.8 from date of entering service to date changed to oil burner, has a record of 7799 engine hours consuming an average of 690 pounds of coal per hour. The same engine has worked 6057 engine hours as oil burner using an average of 1.6 barrels of oil per hour.

690 lbs of coal per hour @ $8.00 per ton,	$2.76 per hr
1.6 barrels of oil per hr @ $1.66 per bbl,	2.66 "
Saving per hour by use of oil----	$0.10 "

The cost of ch-nging Engine No.8 from coal to oil was $769.98; figuring 10 hours per day and 365 days per year, the investment would pay for itself in two years and one month. Recently a contract was made with a firm to furnish California Oil @ $1.46 per barrel, instead of the Texas Oil @ $1.66. As the B.T.U. of the oils are about the same, there will be a further saving, in the case of Engine No.8 when using California Oil, of 31 cents per hour.

The engines are equipped with the Hammell Patent Oil Burner, and while it is generally conceded that fire boxes need renewing more frequently in oil burning locomotives, the experience here has shown a slight advantage in favor of oil. Oil has this further advantage over coal: that the amount of steam, and thereby the ability of the engine to do work is not measured by the strength of the fireman's back; furthermore, the firing of the oil burner is so simple that the fireman can render more assistance to the engineer in the way of taking signals from the train crew.

Summary

Statement No.1

Operations of the Narrow Gage Division of the Cananea Consolidated Copper Co's Railway 1903 to 1910 Inclusive

Year	Total Cost	Freight & other Credits	Net Cost Ore Haul	Ore Tonnage	Cost Per Ton
1903	$115240.20	$19389.00	$95851.20	479256	$0.200
1904	176844.51	73614.05	103230.46	666003	0.155
1905	202677.21	69611.03	133066.18	881233	0.151
1906	196205.80	53932.53	142273.27	1038491	0.137
1907	227593.68	84959.33	142634.35	1198608	0.119
1908	117087.84	55087.68	62000.16	854244	0.073
1909	127704.10	58324.68	69379.42	1145675	0.061
1910	117438.86	65156.93	52281.93	1033522	0.051
Total 8 yrs	$1280792.20	480075.23	800716.97	7297032	$0.110
Ave	160099.02	60009.40	100089.62	912116	0.110

Statement No.2

Statement Showing Saving Made per Year by Reduced Cost per Ton of Ore Haul for each Year Compared with Cost per Ton in 1903

Year	Ore Tonnage		Reduced Cost per ton	Saving Effected
1904	666003	Tons	$0.045	$ 29970.14
1905	881233	"	0.049	43180.42
1906	1038491	"	0.063	65424.93
1907	1198608	"	0.081	97087.25
1908	854244	"	0.127	108488.99
1909	1145675	"	0.139	159248.83
1910	1033522	"	0.149	153994.78
				$557395.34

Statement No.3

Statement Showing Saving Made per Year by Reduced Cost Per Ton of Ore Haul for Each Year Compared with Cost per Ton for each Previous Year

Year	Ore Tonnage	Reduced Cost per Ton	Saving Effected
1904	666003 Tons	$0.045	$29970.14
1905	881233 "	0.004	3524.93
1906	1038491 "	0.014	14538.87
1907	1198608 "	0.018	21574.94
1908	854244 "	0.046	39295.22
1909	1145675 "	0.012	13748.10
1910	1033522 "	0.010	10335.22
			$132987.42

It should be recalled that the percentage of increase in mileage since 1903 is 100.3 % and the percentage in equipment in the same period is 262.5%; thus it is obvious that the Cost of Maintenance of Track and Equipment should be greater now than seven years ago, and this should be remembered in considering the yearly cost of operations. By reference to the above statement it will be observed that the cost per ton has been reduced from 20 cents in 1903 to 5.1 cents in 1910, which according to statement No.2, represents a saving of $557395.34 for the seven years, or on the basis of statement No.3, a saving of $132987.42 for the same period.

It will probably be asked why the railroad was so located and so constructed, and why it required so many years to introduce the reforms that have been discussed, whereby the cost of hauling ore has been reduced from 20 cents per ton in 1903 to 5.1 cents in 1910. As the original line from Ronquillo to Puertecito was built before the writer's connection with the company, he forbears from answering the first question. In reply to the second, it may be said that in a mining camp, the railroad is the poor relation, as it neither mines, mills nor smelts the ore, and that the reforms were made as promptly as the money to institute them was furnished.

An old proverb reminds that "The proof of the pudding is in the eating thereof", and unless this paper has proven that there are many problems worth while to be encountered in the study of the economical transportation of ore for a copper plant, and unless the discussion has shown that the ores are being transported economically, then the cook has muddled the pudding.

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